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2. **Manuscript.** The manuscript submitted should be an original (not a carbon) copy, and typewritten, double-spaced, with 2-3 cm. margins. The title of the article should be followed by the name and address of the author. If the paper has been presented at a meeting, a footnote giving name of society, date, and occasion should immediately follow the author's name. The usual editorial customs, as exemplified in the most recent issues of the JOURNAL, should be followed as closely as possible.

3. **References and Footnotes.** Each reference to the literature and each footnote should be inserted without a number, as a separate line (or lines) immediately following the word to which it refers in the text. A reference to literature should include, in the order named, the title of book or article, author's name, edition or volume, pages, date of publication, and, in the case of books, publisher's name.

4. **Illustrations.** Not all articles lend themselves to illustrations, but articles which do should be accompanied by as many pertinent illustrations as possible. As a rule, apparatus, particulary if complicated, is best presented by means of line or working drawings. Photographs are sometimes sufficient, however. When both can be obtained, it is generally desirable to include both.

Photographs should have a gloss finish and should be at least post-card size—larger, if possible. Only prints which are unblurred and which show sharp contrast between light and dark areas can be satisfactorily reproduced.

Line drawings should be carefully prepared in black ink on plain white drawing paper or blue drawing cloth, twice or three times the size desired in the printed cut; it is convenient, when permitted by the scale required, to have them the size of the manuscript. When coördinate paper is used, it should be printed in blue only, with the important coördinate lines ruled over in black; the black square should in general not be less than ten millimeters on a side; the lines of the curves should be the heaviest, except the frame; points on the curves should be indicated by true circles, not crosses. The numbering of the coördinate axes, the number of the figure, and any necessary explanations of the figure should be written in pencil in the margin of the sheet, as they are usually set up in type rather than reproduced from the drawing. All lines, numbers, and letters that are to be reproduced are to be so proportioned that they will be clearly legible in the cut.

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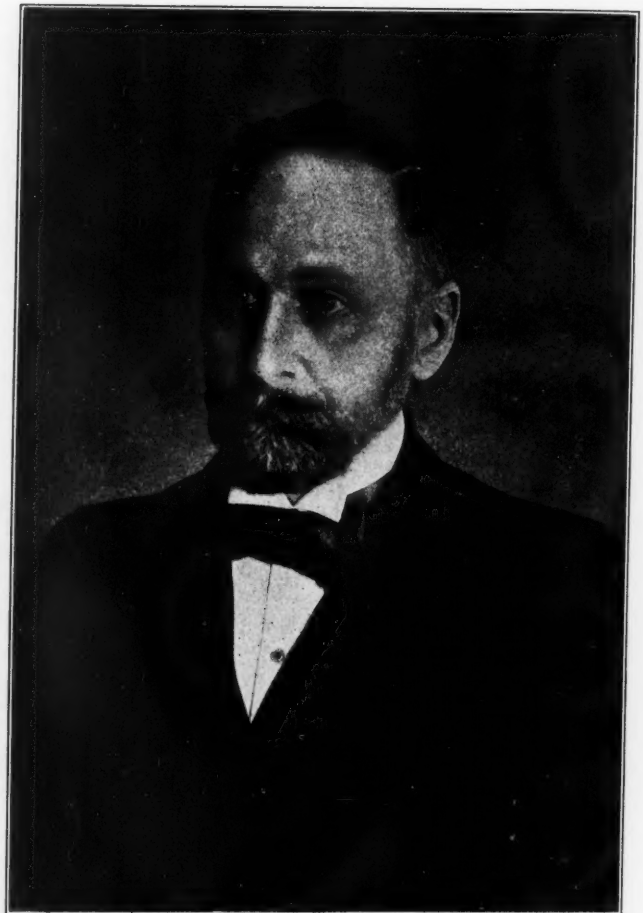

PHOTOGRAV. GEM. STAB. LIT. ANST.

Richard Willstätter.

EDITOR'S OUTLOOK

ON AUGUST 13th last occurred the fifty-eighth anniversary of the birth of Richard Willstätter, a German scientist who has, from his youth, been making important additions to knowledge in the field of organic chemistry, particularly in its physiological phases.

Richard Willstätter, 1872–

Willstätter's early education was received in his native town, Karlsruhe. He later attended the *Realgymnasium* at Nürnberg after the removal of his family to that place. He entered the University of Munich for the study of science at the age of eighteen and there had the great good fortune to work under the stimulating leadership of Adolf von Baeyer in the school of chemistry which he had lately organized. With this excellent start in his scientific life, it is not surprising that Willstätter's natural abilities responded to the advantages of training and environment to make his work in science significant from the beginning. He spent fifteen years at Munich, successively as student, research worker, *privatdozent* and special professor and head of the organic chemistry department.

His research interest, even in youth, was direct and definite. He wished to investigate animal and vegetable pigments and all his early study and experiment as an independent worker were aimed at acquiring the technical knowledge and manipulative skill which he considered necessary to such an investigation. He began to chafe under the narrow regulations at Munich which refused him sufficient freedom for the pursuit of his plans and he snatched at the first opportunity of release that offered. This was an appointment to the deservedly famous Technical School at Zürich, which he accepted in 1905. He has himself pronounced the seven succeeding years in Switzerland as "the most significant and the best" of his life. Here without delay he progressed to the long-anticipated work on chlorophyll, which he found to exist as an active principle, under two forms, in more than two hundred plants which came under his scrutiny. His findings were reported in twenty-four memoirs in the *Annalen der Chemie* from 1906 to 1914, and his studies were assembled in a book, published jointly by himself and Stoll in 1913, under the title, "Untersuchungen über Chlorophyll."

Willstätter has further shown that the chlorophyll of plants and the hemoglobin of the blood may be derived from the same substance, aetioporphyrin, thus demonstrating the striking fact that these primary principles of life in the plant and the animal may be traced to a common origin, though they function oppositely, the hemoglobin being merely a carrier of oxygen while the chlorophyll plays a more important rôle in the assimilative process of the plant by eliminating oxygen and promoting the storage of solar energy.

Willstätter's later work has been concerned with the red and blue

colorings of flowers, which he has found to have a common basis in cyanidine, the reds being merely acid forms of the blues. He has also made extensive studies in an effort to determine the nature of the enzymes.

The Nobel prize crowned Willstätter's work on chlorophyll in 1915, but in the meantime he had left Zürich for an appointment as director of chemical research in the new Institute of Chemistry at Berlin-Dahlem, which carries with it an honorary professorship at the University of Berlin. He left this post in 1916 to accept the signal honor of the invitation to succeed Adolph von Baeyer in the chair of chemistry at Munich.

In 1925 Willstätter resigned from university work. His research, however, has continued, and is regularly reported in current publications. Quite recently he has collaborated with Dr. Duisberg, of Jena, in the successful application of tribromethanol as an anesthetic, medically known as avertin, which has been found to have marked advantages over other anesthetic drugs in operations on the brain and the eye.

Willstätter has for some years past served with three other Nobel prizemen, Wieland, Windaus, and Wallach, in the editorship of *Annalen der Chemie*, and this notable coterie has been lately joined by H. Fischer.

In addition to the Nobel prize, Willstätter's work has been frequently honored, the most important recognition from the English-speaking world being the award of the Faraday Medal. This was presented to him by the Chemical Society at the Royal Institution in London in 1927, thus adding his name to a list of the most noted scientists of his own and many lands.

A brother scientist, Henry E. Armstrong, has thus beautifully estimated the work of Willstätter:

> The chemist who can teach so much of grass, who can also lay bare the secret of color in flowers, may be placed even above the poet. The poet but deals with the superficial and with fancies; at best he is a mere painter. The full beauty of Nature, the structure of her wondrous mechanism, is patent only to the chemist, he is fast learning to interpret her "uniform hieroglyphic" in terms which admit of no dispute..... Indeed the sage of the universe is before us in grass, if we will but read it..... The alphabet in which the story is told, in reality, is one of remarkable simplicity and that so few care to make the attempt to master our shorthand, the language in which our story of flowers is told, is surprising, to say the least. The outward beauty of the flower is patent to every one—the inward beauty of its mechanism, to the seeing eye, is marvelous beyond compare—the man who has done so much to interpret its character may well be deemed worthy among us.

The JOURNAL OF CHEMICAL EDUCATION *is indebted to Mr. Sederholm, managing director of Nobelstifelsen, for the accompanying portrait of Dr. Willstätter and to Dr. Heinrich Wieland (who upon the retirement of Willstätter was appointed to his position at the University of Munich) for biographical notes upon which the above sketch is based.*

Laboratory Exercises in Cultural Chemistry

FROM time to time we have advanced in these columns various notions of our own as to the proper objectives and some of the desirable characteristics of a course in cultural chemistry. It seems necessary, in preface to the brief discussion which we desire to present here, to pass a few of those ideas in review.

All of us who teach elementary chemistry, it is to be hoped, believe that the subject has, or at least can and should have, real values for the students who are to pursue the subject no farther. If it were not so we should find it difficult indeed to justify the presence in the curriculum of a beginning course which constitutes both the beginning and the ending for the vast majority of our students.

Many of us are a little vague as to what those values may be. We cherish some such ideal of education as that expressed by Huxley when he said:

> That man, I think, has had a liberal education who has been so trained in youth that his body is the ready servant of his will, and does with ease and pleasure all the work that, as a mechanism, it is capable of; whose intellect is a clear, cold, logic engine, with all its parts of equal strength, and in smooth working order; ready, like a steam engine, to be turned to any kind of work, and spin the gossamers as well as forge the anchors of the mind; whose mind is stored with a knowledge of the great and fundamental truths of nature and of the laws of her operations; one who, no stunted ascetic, is full of life and fire, but whose passions are trained to come to heel by a vigorous will, the servant of a tender conscience; who has learned to love all beauty, whether of nature or of art, to hate all vileness, and to respect others as himself.
>
> Such a one and no other, I conceive, has had a liberal education; for he is, as completely as a man can be, in harmony with nature. He will make the best of her, and she of him. They will get on together rarely; she as his ever beneficent mother; he as her mouth piece, her conscious self, her minister, and interpreter.

As an ideal this is excellent and inspiring, but as a working guide to the practical teacher it is somewhat lacking. The concept of the mind implied in Huxley's words is one which we no longer believe to be valid. His picture of the educated man includes details which may be attributed to heredity and early environment just as reasonably as to formal education.

Apparently there was a time when educators said to themselves, "The characteristics of great scientists are these. By teaching science to students we shall therefore transmit to them, in some degree at least, these desirable characteristics." They forgot to consider that certain men may have become great scientists by reason of the possession of certain characteristics rather than vice versa. In formulating the objectives of scientific instruction we sometimes fall into the same error and take it for granted that a thorough knowledge of chemistry, or

what have you, carries with it the germs to inoculate the student with certain characteristics which we desire to implant in him.

The difference between a professional course in chemistry and a cultural course in chemistry is fundamental. In the case of the former, the objective is to impart a thorough knowledge of chemistry. The science is an end in itself. In the case of the latter, the science is not an end but a means toward an end—a tool. If the tool is to be properly employed we must keep our attention centered upon the real issue at stake. We can no longer take it for granted that if we teach chemistry faithfully, all these things will be added unto our students automatically. We must direct our energies toward transmitting to our students certain ideas, certain mental attitudes, certain habits of thought, and it is entirely incidental that we employ chemistry as one of the possible media of transmission.

What are some of the ideas and attitudes which we desire to transmit? Some teachers of chemistry believe that we should try to have the student recognize and appreciate the countless invaluable contributions which chemistry has made to our material civilization. We should. But the present writer believes that this should hardly be the sole or the primary objective of a course in cultural chemistry. Such a course should not degenerate into a series of popular lectures on the practical achievements of chemists. Propaganda, to use the word in its less offensive sense, is not very solid educational fare, even though the propaganda be truthful and worthy in motive. It is possible to introduce into any course in elementary chemistry quite incidentally (perhaps in illustration of general principles) sufficient practical applications to give students an entirely adequate idea of the material and economic importance of the science. The newspapers and popular magazines will nobly supplement our efforts along this line.

The writer believes that we can and should attempt to transmit a clear understanding of the nature of a scientific law, a scientific hypothesis, and a scientific theory; that we should leave with the student a clear concept of the functions and applicabilities of these three types of principles.

We should also give them some idea of the nature of the material universe, and we should give them as correct a notion as possible of the scientific method of attacking a problem.

Can we transmit to them the scientific attitude of mind? Hardly that, perhaps, but we can let them know what the scientific attitude of mind is. We can hold up to their admiration the scientific virtues, both by precept and example, and we can point out that these virtues find application in situations not ordinarily considered scientific. If we are sufficiently persuasive and convincing many of our students will

adopt the scientific attitude as a conscious ideal and will actually acquire it to the extent that their emotional and psychological characteristics permit.

These objectives are rather general, but the writer believes that they are the touchstones by which specific units of subject-matter and specific methods of instruction in cultural chemistry should be tested.

Nothing has been said so far of informational material which may be of use to the student in later life. It is often difficult to determine just what information may or may not be useful and in this the teacher must use his own best judgment. It is the writer's opinion that subject matter of this nature may best be handled incidentally and by way of illustration, just as material of the propaganda type may be handled.

These ideas do not, as some people fear, imply that the cultural course in chemistry shall be a superficial or "snap" course, but they do imply that it should differ in aims and in attitude from a "beginning" course in chemistry. Much of the monotonous formal drill in equation-balancing and problem-working which are, or used to be, considered essential parts of the training of a future chemist may well be omitted from such a course. There is no benefit to be conferred by making the student suffer, or by boring him to death either, though some people still adhere to the notion that such discipline has a salutary effect upon the soul.

The point of view which we have presented here has already been rather widely adopted and is evidenced in improved texts and in more rational and less formal classroom instruction. Laboratory reform seems to lag somewhat behind, and in some respects presents more difficulties. We must first abandon the idea that the laboratory course has as one of its primary objectives the teaching of laboratory technic. If the student is not to be a chemist he will have no need of laboratory technic, and a series of exercises designed to exemplify the simpler laboratory operations is utterly pointless. The writer believes we must also free ourselves of the notion that the laboratory course must be illustrative—that is, that every principle, or class of compounds, or type of reaction discussed in the text must have a related laboratory exercise. Educational measurements seem to indicate that the illustrative function is performed, if anything, a trifle better by lecture demonstrations than by individual laboratory work.

The laboratory course in cultural chemistry must strive chiefly after two objectives: to furnish the pupil the satisfactions of creative activity and of independent investigation. We hazard the suggestion that activities of the project type are best suited to achieve these ends. Let the students prepare products in which they are interested and let them solve problems which develop out of directed classroom discussions,

either in the way of resolving differences of opinion or of answering questions raised. They will thus acquire all the technic of which they have need as they go on and they will be applying principles which they are supposed to have learned in class. It might be instructive for many readers to refer to the list of educational objectives and chemical operations and principles involved in the preparation of so simple a product as Karo. [See J. CHEM. EDUC., **7**, 1152–3 (May, 1930).]

This type of laboratory work will never be universally popular among instructors for it calls for mental activity and constant supervision on the part of the teacher. One cannot turn a class loose with cookbook and notebook and settle back to keep order and answer questions.

But this is the only type of laboratory work which will ever have any cultural value. We complain that pupils will not think for themselves, that they seem to have no powers of self-activation. In most cases we have no one but ourselves to blame. No human being will display any startling amount of originality or ingenuity in an operation which bores him. It is only when some interest leads him on that his full powers and capacities are brought into play. Very few of us would waste any thought or activity in trying to answer the question: "How many grains in a cubic centimeter of sea sand?" Our natural reply would be, "Who cares about that?" That is the pupil's natural reaction to the problems posed by the ordinary formal laboratory course. He would have to have considerably less intelligence and sense of proportion than the little we attribute to him to feel otherwise.

Keeping Up with Chemistry

THE case for active participation in the activities of professional organizations should need no urging. The moral obligation and the accruing benefits should be alike obvious. Yet the fact remains that many local organizations, both chemical and educational, do not receive the support which might reasonably be expected on the basis of the professional populations of their territories. The following extract from a letter issued by the Kanawha Valley Section of the American Chemical Society might well be taken to heart by all of us who have been a trifle lax in such matters.

"The biggest single problem facing the professional man, be he doctor, engineer, chemist, or what not, is the job of keeping up with the times. Too many of us feel that the volume of new matter being brought out each year is so great that the very best we can do is to keep up with our particular field. We call it specializing. What it really does is to make us narrow and ultimately to detract from usefulness. We forget that

all science is closely related and that worthwhile advances in one subject always have an effect in other lines. It is not an easy problem but certainly a chemist should follow, at least superficially, all branches of chemistry.

"Another phase of the problem is that few of us are entirely eye-minded. Most of us learn more easily by way of the ear. Consequently, the lectures that make up so much of our college training are particularly missed when we get out in the field. Furthermore, we miss the fellowship of our kind—the society of those interested in the same studies and problems that confront us. Here in West Virginia we are more or less isolated. What we make of ourselves is our own problem. This region is rapidly becoming the leading chemical center of our country. Will those of us who are here now measure up to the responsibilities and opportunities which the next few years will be sure to develop? Or will it be necessary to send outside for men who can do the work? We have the chance of the age but it requires work on our part. Some few of us simply will quit and throw up the sponge. One case comes to mind which will illustrate the quitter type.

"There is a man in this district who came here seven years ago, right out of college. He was ambitious, full of pep, and anxious for work and advancement. Within a short time his whole picture had changed. He is strong and big. Work with his back was easy. Work with his head was irksome. He quit studying. He quit reading. He finally quit discussing his problems with those around him. He wouldn't walk across the street to hear a lecture on anything, much less on chemistry. He simply grew a shell and crawled into it. Atrophy, not bad company, not bad habits, was the trouble. During the past six years he has made no progress whatever. This man thinks the world is against him, that he didn't have the right pull, that his superiors have done him dirt, etc. He doesn't realize that he, himself, is the guilty party."

Chemical Progress in the South

UNDER the accompanying title, Dr. J. E. Mills, formerly of the National Research Council, has compiled and edited an interesting series of manuscripts, covering: Educational Institutions; Chemical Problems of Some Southern Industries; Recent Developments in Chemistry in the South; Statistical Information (on chemical industries); Chemical Periodicals in the Libraries of the South.

Eventually the volume will be published in book form. In the meantime we shall have the honor of presenting this material to our readers in a Southern Number—the October issue of the JOURNAL.

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THE DIALYZER

1. What living chemist has contributed significant data to our knowledge of the coloring matter, especially chlorophyll, of plants? (pp. 1984–6.)

(*For questions* 2–6 *see* pp. 1993–2029.)

2. What constitutes a soil?
3. Name the fourteen elements which normally constitute more than ninety-nine per cent of the mass of life materials.
4. What are the four main groups of soil constituents and how does the climate affect soil structure and composition?
5. What is the modern conception of the structure of a "soil crumb"?
6. What effect does lime have on soil fertility?

(*For question* 7–10 *see* pp. 2035–54.)

7. Name five factors which have been largely responsible for the development of chemistry teaching in the southern colleges during the past half century.
8. Do the southern universities on the whole include technical courses in their curricula?
9. What is the present attitude of the South regarding chemistry courses in preparatory schools?
10. Name seven teachers of chemistry who have served in southern institutions for 50 years or more.

11. Name and characterize two saturated hydronitrogen compounds. Two unsaturated ones. (pp. 2055–62.)

(*For questions* 12–15 *see* pp. 2063–76.)

12. List several alchemical books of the sixteenth and seventeenth centuries, giving titles and approximate dates of publication.
13. What do the following terms mean: cucurbitae, fistulata, rostrata?
14. How did the alchemist's knowledge of nature guide him in his choice of the vessel and receiver to be used for a given distillation?
15. Describe in detail one fractionating apparatus used during the 16th century.

(*For questions* 16–18 *see* pp. 2077–87.)

16. How have the following investigators contributed to the development of the new quantum mechanics: Heisenberg, Born, de Broglie, Schrödinger?
17. What two American physicists have presented experimental evidence which confirms the wave nature of matter?
18. State the Heisenberg Indeterminism Principle.

19. What are the objects of the Institute of Metals? (pp. 2088–93.)
20. How may the blackboard be used effectively in first-year organic chemistry? (pp. 2115–8.)
21. How may the lever principle be applied to the teaching of the solubility product principle? (pp. 2119–23.)
22. What are the arguments in favor of recording valence and ions in terms of electrons? (pp. 2124–6.)
23. How may the configuration of the monosaccharides be presented successfully by means of charts and equations to an organic chemistry class? (pp. 2131–40.)
24. What new gas, claimed to be fireproof and non-poisonous, is now being developed as a refrigerant? (p. 2164.)
25. What type of apparatus would you use to demonstrate nitrogen fixation to your classes? (pp. 2167–9.)
26. What revisions in curricula have recently been made at the University of Wisconsin and the George Washington University? (pp. 2179–80.)
27. What facts support the statement that "the chemist may well be classed as a detective in connection with law enforcement"? (p. 2188.)

THE LIFE LAYER OF THE WORLD

R. R. McKibbin, Macdonald College, Quebec, Canada

In a speech delivered in New York two years ago, Dr. R. A. Millikan pointed out (*1*) that "from an engineering standpoint the universe may be said to be made up of the primordial positive and negative electrons, and of four elements built out of them, namely, helium, oxygen, silicon, and iron." He went on further to say, "Mankind, if he is here a billion years hence, will be satisfying his main needs, as he satisfies them now, with the four elements, hydrogen, oxygen, silicon, and iron, that is, with water, air, earth, and iron.....These fundamental facts may some time help to stabilize the stock market."

World Structure

Out of what stuff is the world, our planetary home, made? We know that there are 92 elements that may occur under our conditions on earth, and that 90 of them have been isolated, named, and studied. But what facts as to the composition of the earth are known? The theory as to the "start in life" of the earth, that is most widely accepted by "earth scientists" or geologists, is that a couple of billion years ago another giant star of our particular galaxy of stars came bumbling along in seemingly aimless fashion rather uncomfortably close to our sun. Since "matter attracts other matter with a force inverse to the square of the distance separating the bodies," something had to give way when these two starry giants were playfully tugging away at each other in such proximity. Apparently a succession of blobs of fiery sun-stuff was pulled out beyond the most immediate and intimate sphere of influence of the sun. These great blobs of matter were not, however, pulled entirely away from the sun's influence, but remained obedient to him, revolving at different distances in orbital paths around him. These pulled-out giant drops of sun-stuff constituted the nuclei upon which the planets as they exist today have been built up.

This theory, which we owe to Chamberlain and Moulton (*2*), is known as "the planetesimal hypothesis," and it is supported by a great many known facts. It gets its name from the postulation that ever since the planetary nuclei left the sun they have been increasing in girth and mass by the addition of smaller "planetesimal" bodies which continually smash into them from outside. It is quite conceivable that at one time in the earth's history there may have been a much heavier bombardment of meteorites on it than there is now. A conservative estimate of yearly additions of weight to the earth from this source would be many hundred thousand tons. It is fortunate for mankind that now relatively few giant meteorites crash into our earth. A few years ago in Siberia one of them smashed into the earth with such a tremendous impact that the wind created by the displaced air overthrew trees for many miles around, all with their tops pointing out from the center of disturbance. Because it was an entirely unpopulated district no loss of life resulted.

"The planetesimal hypothesis" as to the origin and growth of the earth has replaced the Laplacian hypothesis, which stated that at the beginning of the solar system the sun filled all the space at present occupied by the planetary orbits. With loss of heat by radiation it shrank and its rotation velocity increased. At different stages in its contraction gaseous rings were left behind which by gravitation of their parts toward each other concentrated into planets. By the Laplacian hypothesis the earth and the other planets are supposed to have contracted from a more diffuse state into their present state. It postulates a static geology, as opposed to the planetesimal hypothesis, which expresses belief that the earth has grown from a smaller nucleus to its present dimensions.

Of what are these planetesimal bodies composed, that are believed to have built up the earth to its present size? Table I (*3*) gives the average found and recalculated results of a great many analyses of meteorite "cores" that have reached the earth's surface. This is just the inner, denser portion of the planetesimal bodies that flare into incandescence from the friction of the earth's atmosphere. Most of even the larger meteorites will disappear as "dust" before reaching the lithosphere. We should not, therefore, expect too great similarity in composition between the earth and the meteorite cores that have been analyzed.

TABLE I*

Average Composition of Stony Meteorites

Components	*Actual average found*	*Recalculated to 100% after rejecting admixed nickel-iron sulfides and phosphides*
SiO_2	38.98	45.46
Al_2O_3	2.75	3.21
Fe	11.61	...
FeO	16.54	19.29
CaO	1.77	2.06
MgO	23.03	26.86
Na_2O	0.95	1.11
K_2O	0.33	0.38
MnO	0.56	0.65
Chromite	0.84	0.98
Ni, Co	1.32	...
S	1.85	...
P	0.11	...
	100.64	100.00

* After Merill.

In Figure 1 is given a graphic representation of what the structure of our earth is thought to be. In the interior mass, or centrosphere, there is great rigidity. For several different reasons the centrosphere is believed to be very largely composed of the elements iron and nickel. Among these

reasons are (1) the composition of meteorites, (2) the fact that earth waves passing through the centrosphere are transmitted as they would be by a body formed of these two elements, (3) the weight of the earth. Outside the centrosphere (which is believed to be several thousand miles in diameter) lies a layer several hundred miles thick which is regarded as the weakest and most yielding part of the "solid" earth. This layer, termed the asthenosphere, is composed very largely of the lighter elements, aluminum and silicon. Within the asthenosphere, which is probably partly in the liquid state, readjustments and easement of strains are believed to take

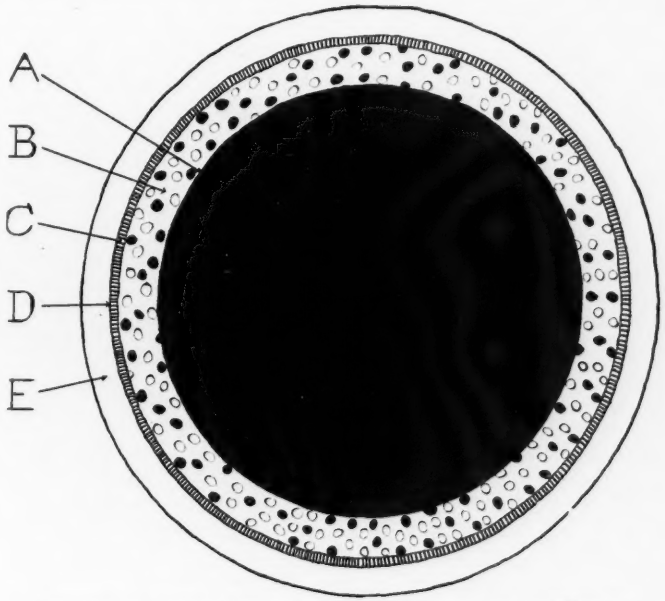

FIGURE 1.—DIAGRAM SHOWING THE MAJOR LAYERS OF THE WORLD

A—the centrosphere *C*—the lithosphere (includes the hydrosphere) *D*—the life layer
B—the asthenosphere *E*—the atmosphere

place readily. Outside the asthenosphere comes the solid crust of the earth, which is much more rigid. The earth's crust, known as the lithosphere, is probably forty or fifty miles in thickness, and like the asthenosphere is largely made up of the two elements, aluminum and silicon. Aluminum and silicon are much lighter elements than iron and nickel. It is just as in a blast furnace; the heavier metals work down to the bottom (in this case the center) and the lighter elements rise as slag. In Table II is shown the estimated average composition of the outer part of the lithosphere.

TABLE II*

Average Composition of the Lithosphere

Components	*Nature of rock*				*Weighted average*
	Igneous	*Shale*	*Sandstone*	*Limestone*	
SiO_2	59.14	58.10	78.33	5.19	59.08
Al_2O_3	15.34	15.40	4.77	0.81	15.23
Fe_2O_3	3.08	4.02	1.07	0.54	3.10
FeO	3.80	2.45	0.30	...	3.72
MgO	3.49	2.44	1.16	7.89	3.45
CaO	5.08	3.11	5.50	42.57	5.10
Na_2O	3.84	1.30	0.45	0.05	3.71
K_2O	3.13	3.24	1.31	0.33	3.11
H_2O	1.15	5.00	1.63	0.77	1.30
TiO_2	1.05	0.65	0.25	0.06	1.03
CO_2	0.101	2.63	5.03	41.54	0.35
S	0.052	...	...	0.09	0.049
P_2O_5	0.299	0.17	0.08	0.04	0.285
MnO	0.124	...	...	0.05	0.118
C	...	0.80	...	...	0.040
SO_3	...	0.64	0.07	0.05	0.026
Sum of all other constituents—each less than 0.1%	0.324	0.05	0.05	0.02	0.302
	100.000	100.00	100.00	100.00	100.000

* From "Data of Geochemistry," by Clarke, 5th ed.

The next layer of the earth is the atmosphere, composed largely of nitrogen and oxygen, two still lighter elements. The atmosphere is a layer probably several hundred miles in thickness. There is some evidence that in the upper atmosphere there may exist another layer of still lighter stuff, electrons.

Mankind lives at the junction between the upper part of the lithosphere and the lower part of the atmosphere. He cannot live more than a mile or so "up" or "down" from this junction point between the atmosphere and lithosphere. With our bodies surrounded by the gaseous atmosphere, and except when we are in airplanes or balloons, supported by the solid lithosphere (or else by the hydrosphere, as the surface water of the earth is termed) we are truly creatures of an environment from which we cannot physically escape. We move about at the bottom of the atmospheric layer, never more than a few feet removed from the outer surface of the lithosphere. We are creatures composed of nearly eighty per cent water. Through the protective action of our blanketing earth atmosphere the necessary narrow range is maintained of temperature, moisture, pressure, oxygen concentration, and of other conditions, within which we can exist. There is a constant interchange of matter (chiefly in the gaseous state) taking place between lithosphere, hydrosphere, and atmosphere, by means of which equilibrium is maintained and organic beings can survive.

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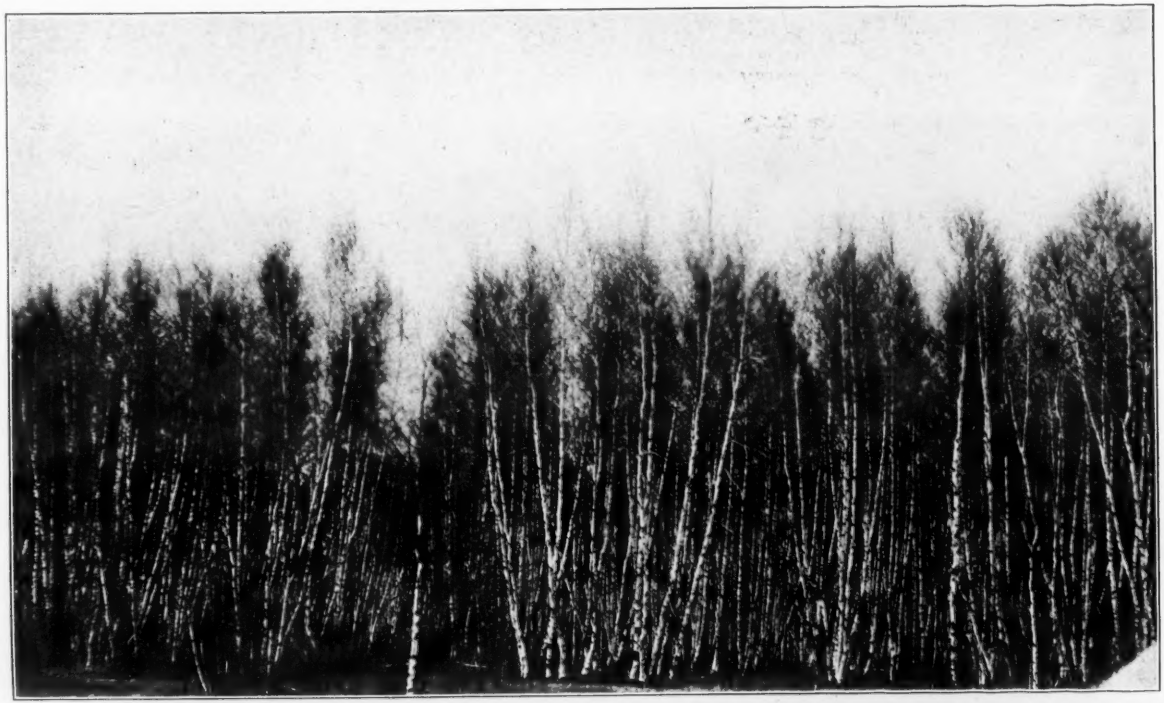
GLACIAL DEBRIS IN COOK INLET COUNTRY, ALASKA
No true soil has formed.



THE PAPER OR CANOE BIRCH (*Betula papyracea Ait.*) VERY COMMONLY OCCURS ON PODZOL SOILS

U. S. Dept. of Agriculture

TUNDRA-LIKE REGION, COPPER RIVER BASIN, ALASKA

The "Life Layer" of the World and Its Study

As far as we know the only place that life of any kind can continue to exist is in this junction layer between the lithosphere, the hydrosphere, and the atmosphere. In the lithosphere there occur both water and gases, in the hydrosphere there are both solids and gases in solution. In the atmosphere there are much water vapor and much finely divided solid matter. Wherever life occurs we find solids, water, and gas.

Nearly all the land animal life and practically all of the land plant life except the tops of trees are in a state of nature concentrated in a soil and lower air layer of the world less than 20 feet thick. Some microörganisms and many of the seeds of plants may survive for a long time in the atmosphere or deeper in the lithosphere, but they must eventually return to the "life layer" of the world. It is a striking fact that carbon, nitrogen, and oxygen (with atomic numbers 6, 7, and 8; atomic weights 12, 14, and 16) are among the most important, if not actually the most important "life-forming" elements. Silicon, phosphorus, and sulfur occur in the periodic classification of the elements directly below the first three mentioned and these six elements together with hydrogen, sodium, magnesium, aluminum, chlorine, potassium, calcium, and iron make up nearly all of living tissue. There are, of course, other elements whose presence in small quantities is essential to life (for example, iodine and fluorine), but the fourteen elements first mentioned normally constitute more than ninety-nine per cent of the mass of life materials.

It is as "the life layer" that I wish to define the thin outer soil layer of the land areas of earth. If we want a further more or less air-tight definition of

THE SUGAR MAPLE, BEECH, AND SILVER BIRCH ARE FOUND ON LESS PODZOLIZED SOILS

soils, here it is: *Soils are masses of weathered mineral and rock fragments of different sizes, of diverse origin, and in varying percentages; mixed with organic matter from various sources, in different stages of decay, and likewise in each soil forming a different percentage of the whole. A true soil must have in it microörganic life, plant and animal in nature. Before it can support life it must have a considerable quantity of water, and in this water, known as the soil solution, there will be found many different soluble substances, originally solid, liquid, or gas. A soil atmosphere will be present in all but the most water-logged soils.* This definition is extremely long. There are many undefinable things and perhaps soils should be included among them.

THE AMERICAN ELM THRIVES ON FLAT GLACIAL CLAY LANDS

Soil science is quite young. It is an offspring of geology. The first essential thing that must be done by any science in its own field is classification. The systematic classification of their soils is well advanced in many countries. The two leading countries of the world in this respect are the United States of America and the Union of Soviet Socialist Republics, better known to us as Russia. In the United States the classification of soils has chiefly been carried out by the Federal government working through the Department of Agriculture and the work, started by the late Dr. Milton Whitney, has been very largely under the efficient direction of

U. S. Dept. of Agriculture

SPHAGNUM PEAT BOG, CHESTER CREEK DELTA NEAR ANCHORAGE, ALASKA

U. S. Dept. of Agriculture

ALKALI SPOTS LOOKING EAST FROM DOUBLE BUTTE, NEAR TEMPE, ARIZONA

one individual, Dr. Curtis F. Marbut. About fifty per cent of the land area of the continental United States has been classified into different soil provinces (or regions), series, and types.

The United States system of soil classification (*5*), (*6*) has been developed to take into account variations in the geological origin of the mineral portion of soils, climatic effect on soils, plant ecological variations, and many other factors which the skilled soil surveyor recognizes with ease in the field. Profiles (exposed sections cut down through soil and subsoil) of uncultivated land are examined and the number and thickness of the different layers in the soil are noted. Chemical determinations are made on each of the layers (termed "horizons" by the soil surveyors). The color and texture of each horizon are examined. Areas having soils essentially alike are grouped together and an identifying name is given to the whole. Thus, "Sassafras silt loam" and "Leonardtown silt loam" are different areas of soil occurring in the Atlantic Coastal Plain province, of Sassafras and Leonardtown series, respectively, and both of silt loam type. There are important chemical and physical differences between these two kinds of soil which are reflected in the nature of the crops best adapted to each, in their relative need of specific fertilizers and in their natural mechanical condition.

The final result of the soil survey of a given unit of area (generally a

county) is the publication of a description of the soils occurring within the area. The most valuable part of the published results of a soil survey is the map, generally having a scale of one inch to a mile, which portrays the extent of the different soils encountered. These maps are invaluable to any one who wishes to know the nature of the soil at any given point. Such soil maps are generally obtainable from state agricultural experiment stations. Primarily the United States soil surveys have been designed to be of value to farmers and to those who are helping to disseminate information to farmers.

It is claimed by some that the Russians have put the bones and sinews into soil science. At any rate there has emerged from that vast land a system of soil classification that is applicable the world over. For many years the collection of taxes from the peasants in Russia has been based upon information gained from soil classification. The government has perhaps been more interested in soil classification than the people have. The Second International Congress of Soil Science was held in Leningrad, U. S. S. R., in July, 1930. The first was held in Washington, D. C., in June, 1927. In both cases the convention of scientists was followed by a trip throughout the country in which it was held to enable the visitors to study the soils.

The late Doctor K. D. Glinka was one of the modern Russian leaders in soil classification (*7*). The Russian conception (*8*), (*9*) of the differentiation of soils is that they owe their chief characteristics to the nature of the climate. "Necessarily," they say, "the soils of cold climates must differ greatly from those of hot regions, and those of humid climates from soils of arid areas." In Figure 2 is shown a map of the world in which high, medium, and low rainfall areas are delineated. By means of the system of classification that the Russians have developed one can confidently predict the general nature of soils that will normally be encountered in any part of the world.

Soils and Soil Structure

There are four main groups of soil constituents. Upon the dominance of one or more of these groups of constituents depends the character of a soil. The nature of the climate in which the soil occurs will very largely determine which of the groups of constituents will be dominant and the condition in which these constituents will be present. The groups are:

1. The sesquioxides of iron and aluminum,
2. Silica,
3. The strong bases: Ca, Mg, K, Na,
4. Organic carbon compounds.

Let us in imagination start at the poles of the earth and work toward the equator. Beneath the polar ice sheets we do not expect to find true soils.

FIGURE 2.—THE GREAT DIVISIONS OF THE WORLD ACCORDING TO THEIR MEAN ANNUAL PRECIPITATION

Life in the Arctic and Antarctic polar regions is confined to the sea and to adjacent ice-clad shores. Advancing a little farther from the poles toward the equator we reach the land of the tundras, where in summer some inches of the surface soil may thaw out and where lichens, mosses, and a few flowering plant species exist. Some of the southernmost islands between South America or Tasmania and the South Pole, and vast stretches of northern Siberia and of northern Canada, are typical tundra regions. One hesitates to apply the name of soil to the outer layer of the crust of the earth in these regions, but at any rate it supports life and will answer to the general definition given for soils.

The next main "belt of soils" below the tundras is termed by the Russians "podzol." These soils are sometimes called "gray earths" or "forest soils." They are relatively high in silica, low in the strong bases, low in iron and aluminum, and until the final stages of leaching (or podzolization) they are quite high in semi-decomposed organic matter, which is well described by the Germans as "roh humus." These podzols occur in cool, humid climates and are generally open-textured, sandy, or gravelly soils, deficient in strong bases. They present a tri-colored appearance.

Under Quebec conditions the top layer (roh humus layer) is mostly semi-decomposed carbonaceous material very black in color and of varying depth. Below the black layer appears a bleached and leached "ashes color" layer, also of varying depth. Organic acids from the roh humus layer are effective solvents of soil minerals. Below this is a layer of rusty red color, in which some of the sesquioxides leached from above have accumulated. Concretions of iron and aluminum oxides with organic matter are often present in this layer. Below the reddish layer will be found sand and gravel usually to a depth of many feet. On the North American continent the podzol belt includes a large part of the New England States, most of the south half of Quebec (although there are many "glacial till" clays of excellent fertility), northern Ontario, and there are podzol-like soils in the northern parts of the western Canadian provinces. In South America the southern half of Argentina (part of Patagonia and Tierra del Fuego) has many podzols. Nearly one hundred years ago Charles Darwin, one of the greatest observers the human race has had, remarked the great accumulation of semi-decomposed organic matter in many of the forests of Tierra del Fuego and the light coloration of some Patagonian soils (*10*). In Figure 3 is given a graph of a typical podzol. The podzol belt soils are generally very acid. On some of the most advanced podzol soils, organic matter has almost disappeared and silica is the dominant soil constituent. Within the podzol soil belt there may occur limestone soils and other soils that are well supplied with minerals, but these are exceptional.

It must be understood that these vast "earth belts" of soils are very irregular in width, and that they are mixed up with each other. In the last

paragraph the presence of relatively great amounts of silica and of organic matter in the soils of moist, cold climates was emphasized. Under water-logged conditions such as those met with in swamps and bogs, organic matter accumulates almost to the exclusion of the other main groups of soil-forming constituents. Throughout eastern, central, and northern Canada and in the northern United States there are many millions of acres of peat bogs, in which organic matter is distinctly dominant.

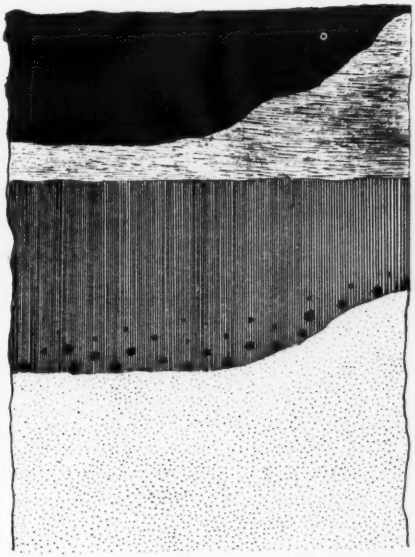


FIGURE 3.—DIAGRAM SHOWING THE LAYERS IN A VIRGIN PODZOL SOIL

At left podzolization definite but slight compared to extreme podzolization at right.

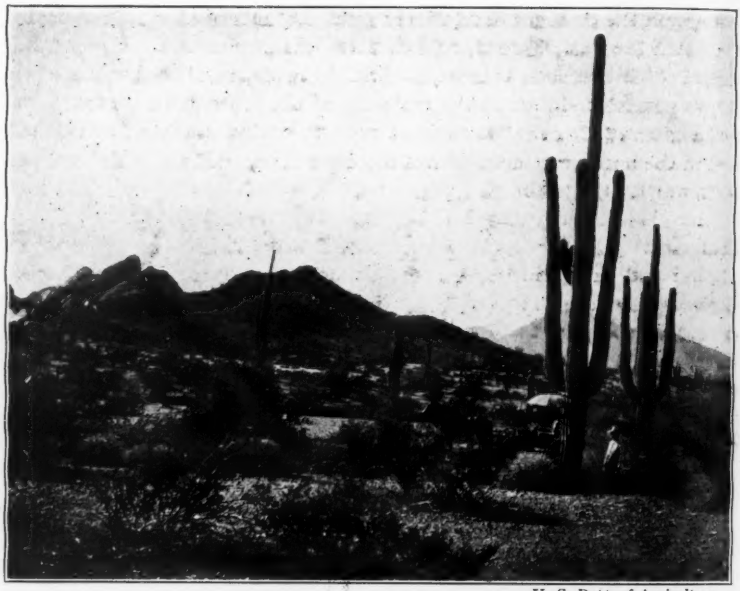
"A" *Horizon* { *A*—high organic matter layer, "roh humus"; *B*—leached layer, bleached white

"B" *Horizon* *C*—rusty-red iron-rich layer with "ortstein"

"C" *Horizon* *D*—parent material—sandy, gravelly, or stony

Semi-arid and arid climates have a great effect on soil conditions, whether their soils occur in hot or in cold regions. Under conditions of little rainfall the strong bases tend to accumulate. Evaporation of water from the soil exceeds rainfall, so there is little leaching. Under some arid conditions both alkali metals and alkaline earths tend to accumulate. The Russians name those arid climate soils containing alkali carbonates, "Solonetz," and others which contain neutral salts, "Solonschak."

Certain semi-arid conditions, exemplified in the great spring wheat-growing districts of the western United States and Canada, are such that organic matter can accumulate in the soils to a considerable extent. In warmer climate, semi-arid regions, and where there is more even distribution of rainfall throughout the summer, the lack of organic matter in the soils is perhaps their greatest deficiency. The black, high organic matter soils, rich in strong bases and particularly rich in calcium, are named "Tschernozem" by the Russians. These soils, found in the wheat-growing areas



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DESERT VEGETATION, SALT RIVER VALLEY, ARIZONA

of Russia as well as in our west, are probably the most fertile soils in the world, although corn belt farmers, whose land lies on the eastern fringe of the North American tschernozem area, may have the right to protest at this statement.

As a general rule it may be said that semi-arid and arid climate soils have a relatively high percentage of strong bases and are deficient in organic matter. Silica and the sesquioxides fall into the background slightly in these soils although they are usually relatively more soluble in strongly alkaline soils of arid climates than they are in cool, humid climate soils. Intelligent application of water to arid soils results ordinarily in making possible the growing of tremendous crops. Hilgard points out (*11*) that the average size of a farm unit in the eastern United States during the early years of this century might be considered as from forty to one hundred sixty acres, while in the irrigated arid lands of the west ten acres was under a different system an area of ample size to constitute a farm. It is a striking historical fact that the most ancient civilizations were erected on arid soils. Egypt, obtaining her irrigation water from the Nile, lay on the edge of the Libyan desert. Babylon and Chaldea, Assyria, Phoenicia, and Judea all were arid climate or semi-arid climate civilizations. The fertility of desert soils, when they are given water by those who know

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SHOWING SPARE GROWTH OF TREES ON A LATERITE SOIL, NIPE MOUNTAINS, EASTERN CUBA

how to apply it, is phenomenal. The important part played in soil fertility by the strong bases of the soil is at once apparent from this statement.

Before we wander too far away from our path, in our imaginary journey from the poles to the equator, we had better return to it. Farther down toward the equator than the podzol, glacial clay, and tschernozem areas, the "brown earth" soils are to be found in humid climate regions. In these there is much better distribution of organic matter, sesquioxides and strong bases, throughout the different horizons, than there is in the podzols. There is, however, still a tendency toward acidity in the brown earths, although their acidity is generally not so pronounced as is that of the podzols. The countries of central Europe and the central eastern United States fall mostly into the brown earth soils area, as well as many of the soils of South Africa and of south central South America.

In the United States, from Virginia southward, the soils acquire more and more of a reddish color. This is because of their gradually increasing content of iron. South temperate, sub-tropical, and tropical soils, under moist conditions, generally are high in iron and aluminum and (except in water-logged areas such as the Florida everglades) they usually contain less organic matter than those of colder climates. There is relatively much less silica in warm climate soils than in northern ones. Iron accumulates in these soils and so also does aluminum. The bauxite deposits of Demerara arise from this primary cause. These red-colored warm-climate soils, which possess a very low $SiO_2/Fe_2O_3 + Al_2O_3$ ratio, and which form under conditions of ample moisture supply, are called "laterites" and the process of

their formation is known as "lateritization." True lateritic soils are usually ill-supplied with strong bases. In Cuba the United States Soil Survey workers have studied the laterite type of soils. Bennett describes them very clearly (*12*).

The fact has been emphasized that organic matter tends to accumulate in cold humid-climate soils and tends to disappear from warm, non-swampy, humid-climate soils. This may be taken as an index of the potential "life energy" within the two kinds of soil. Tropical soils produce luxuriant jungle vegetation, this dies and becomes soil organic matter. The processes of decay are so speedy in tropical soils that organic matter quickly "fades away," due to microörganic action, in the form of such end-products of decay as CO_2, nitrate nitrogen, and water. The CO_2 concentration in jungle air consequently is very high, and the nitrate nitrogen leaches away in soil drainage water in relatively great quantity.

While in podzols and brown earths the accumulated semi-decomposed organic matter is a source of organic acids, which profoundly modify soil conditions by their action, in ordinary well-drained moist-climate tropical soils the processes of decay are so rapid that organic matter quickly rots, producing CO_2, and the silica tends to leach away due to the action of basic carbonates and bicarbonates.

Within the climatic belt where base-rich laterite soils occur there are to be found many acid soil regions. For example, the soils of Trinidad, which have arisen originally from Orinoco River alluvium, are mainly acid.

Before we discontinue our imaginative trip from the poles to the equator let us make some further observations. Over a wide zone on either side of the equator there is normally a region of very great rainfall. The tropical "rain forests" are among the wettest places to be found anywhere on the solid earth. Next there is a band of regions of less humidity, and then a girdle of arid lands which varies much in width from north to south, and which extends right around the world. High mountain ranges and the direction of ocean currents have much to do with the extent of aridity in these lands. In the southern hemisphere the west coast of South America is arid, in Australia a great portion of the island-continent is desert land, and in South Africa the Kalahari desert exists, surrounded by semi-arid lands. In the northern hemisphere, with its greater land masses, the west central part of North America is arid or semi-arid; in Asia the desert of Gobi, the arid regions north of Tibet and Afghanistan, and the peninsula of Arabia lie in this band; in Europe the tip of Spain; in Africa the enormous extent of the Sahara desert and the aridity of Somaliland testify to the continuation of the "dry belt."

Not all the arid and semi-arid lands of the world are warm lands. Bitterly cold conditions are met with at times, for example, in the Gobi and on the Tibetan plateau. Due to the intervention of other factors, as has been

Photo by Mathews, Tropical Plant Research Foundation

LUXURIANT TROPICAL VEGETATION, PALMS AND HARDWOODS, IN LOWLANDS OF EASTERN CUBA

pointed out, there may occur within the recognized "belts" of quite similar climatic conditions, soils of an entirely different nature to the majority of soils in the area. Thus, Arctic soils will be encountered on high mountains in the tropics; forest soils occur away up in the tundra region along a strip warmed by the Mackenzie River; comparatively newly laid down glacial or sedimentary soils in any area will differ in character from the aged soils of that area that have been long exposed to climatic conditions.

The Soil as a Colloidal System

So far we have dealt with the genesis of soils and their response to environmental conditions, as well as with their general relation to the mundane scheme of things. Under the first heading of this paper, **World Structure,** page 1993, the position of the soil layer of the earth, in its relation to other layers, was considered. Some information was also given as to the empirical composition of the outer crust of the globe we inhabit. Under the second heading, **The Life Layer of the World and Its Study,** page 1998, American and Russian methods of soil classification were outlined and a definition of soils was attempted. Under the heading, **Soils and Soil Structure,** page 2004, the main groups of soil constituents were discussed and the tremendous effect of climate on soil structure and composition was stressed. In the remainder of the paper there will be discussed more particularly the conditions existing within soils.

It has previously been pointed out that soils must have present in them both organic matter and mineral matter. If we are tempted to consider the soil as a living thing, which may almost be permissible, from its intimate relation to living organisms and because of its dynamic properties, it is well to point out that instead of there being one central atom "to hang things on" as there is in organic life, in the soil there are two central atoms to consider. The carbon atom is rightly considered to be the central atom of the organic world; organic chemistry is often defined as "the chemistry of the carbon atom." In soil the silicon atom, as well as the carbon atom, occupies a central place. The fact must not be overlooked, however, that without carbon (that is to say, without organic matter) there are no soils. Silicon and carbon are, respectively, the bones and the viscera of soils.

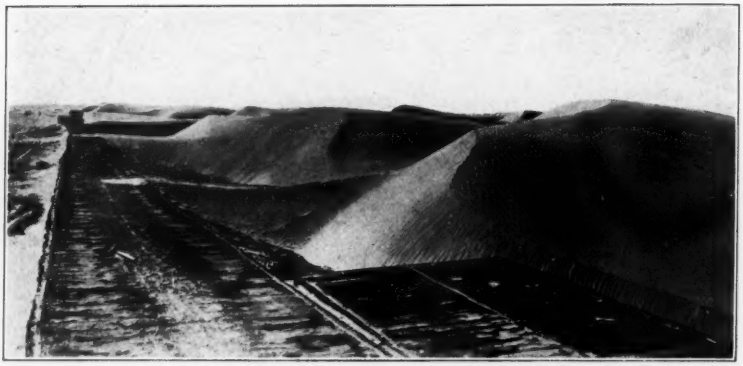
By all odds the most important solid part of soils is the soil colloidal matter. It may be divided into two parts—mineral and organic—for the purpose of classification, but in soils there is no such arbitrary division. Considering, however, that we have mineral and organic colloidal material in the soil, we may discuss the soil as a colloidal system. Mineral colloids in this classification fall into the clay fraction of soils, which may be determined by physical methods. At the heart of the mineral colloidal matter the two elements silicon and aluminum predominate. Iron, potassium,

Photo by F. M. Bain

LUXURIANT TROPICAL VEGETATION "ROPE-VINES" OR LIANES, IN PORT OF SPAIN, TRINIDAD, B. W. I.

calcium, magnesium, sodium, phosphorus, manganese, and so on, normally occur in the clay fraction of soils. Organic colloidal material in soils cannot so easily be measured by physical methods as the inorganic colloidal material. Yet its importance in the soil is tremendous. Within the organic colloids of the soil the elements carbon, nitrogen, sulfur, and phosphorus are important.

It is hard to overestimate the importance of the physical effect of organic matter in regulating soil conditions. The tendency for organic matter to



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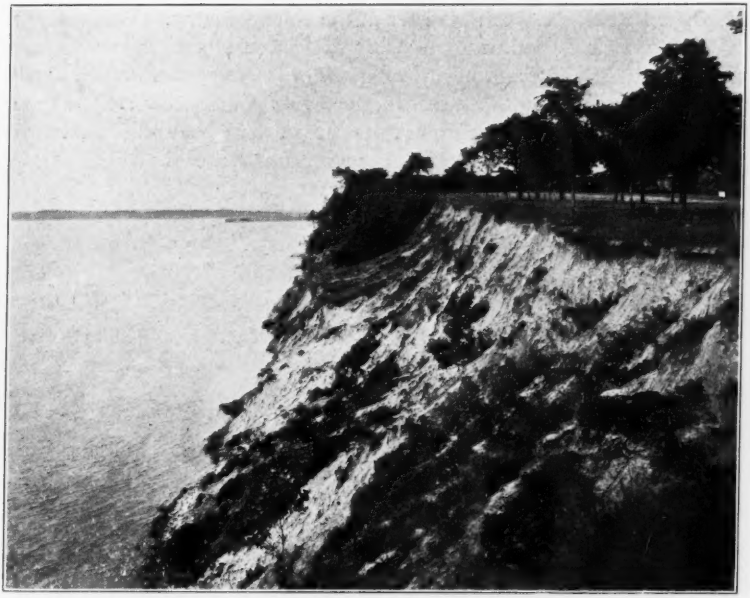
SAND DUNES ARE NOT SOILS

Old plank road over desert between Colorado River and Imperial Valley of California.

accumulate and for metals to leach out of cool, humid climate soils has been mentioned previously. In those soils in which there is a high percentage of clay one of the most difficult things to control, in any climate, is erosion. Streams running through clay regions in Quebec Province (the soils of which clay regions contain relatively less organic matter than those of other parts of this province) are always muddy and carry much colloidal material in suspension. Throughout the length and breadth of the Mississippi valley erosion of surface lands is for several reasons (soils and otherwise) one of the most serious problems facing the United States today. This erosion occurs in other great river basins also, especially in wind-deposited soils of extreme fineness of particle size. The enormous amount of sediment discharged by the Mississippi River into the Gulf of Mexico annually contains much of the most highly fertile parts of the soils through which that river and its tributaries flow.

It is no mere coincidence that rivers which arise in forests and which flow through districts having soils well supplied with organic material are "clear water" rivers. To those observers who go from "muddy water country" to "clear water country" the tremendous effect exerted by high organic matter soils in reducing the amount of suspended material in streams and rivers comes as a revelation. Streams and rivers are normally "soil solution" which has seeped and percolated to lower levels. Streams that flow with clear water do not contain much surface run-off water, but their water filters through soils which are capable of retaining much of the suspended material which might otherwise wash away.

An outstanding property of colloidal matter in general is that it presents great surface relative to total mass of material. Linked with this property and of paramount importance in soils is the property that colloids have of



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THE DRAINAGE SYSTEM OF THE SOILS OF CENTRAL NORTH AMERICA
Mississippi River at Memphis, Tennessee.

adsorbing specific ions from solution and holding them in loose chemical union. A widely accepted view as to the distribution of inorganic colloids in the soil is that they are mostly collected, in gel form, around nuclei of larger mineral soil particles. Gile (*13*) expresses the views of modern soils workers in this connection. The soil crumb, or aggregation of small particles, is like a mosaic of organic and inorganic materials, with aluminum and silicon predominating. The surface of such a soil crumb is regarded as carrying an excess of negative electrical charges. Cations diffuse from the soil crumbs into the soil solution surrounding them, and an electrical double layer results at the boundary between solution and colloidal solids. This conception is illustrated in Figure 4 (page 2016)

A phenomenon known to soils students as "base exchange" was first observed by the Englishman, Way, nearly 80 years ago (*14*). The full significance of Way's work was not appreciated until the present century. During the last ten years the study of base exchange has leaped into a very prominent place in the attention of soils students.

The great absorptive power of soils for odors, fertilizer salts, water, and so forth, is apparent to every one. All the significant absorption of ions that

takes place in soils is due to matter in the colloidal state. Thousands of soils workers have confirmed the observation that when soils are treated with fairly dilute salt solutions, the cations of the salt are adsorbed by the soil colloid material (the "base exchange complex") and an equivalent quantity of cations passes into solution from the previously adsorbed state. It is not a simple metathetical reaction but a replacement of the soil cations by other cations. Calcium ions, hydrogen ions (in "unsaturated" soils), so-

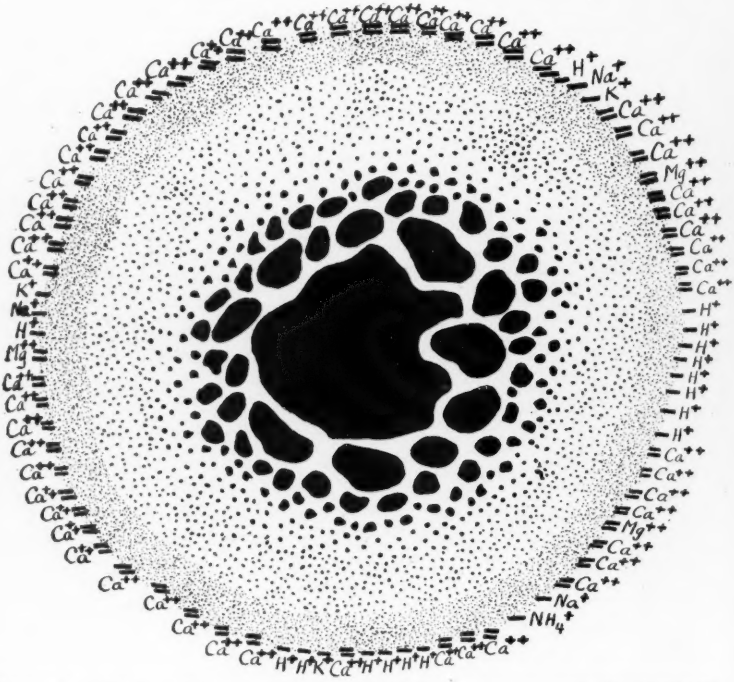

FIGURE 4.—DIAGRAM ILLUSTRATING MODERN VIEWPOINT AS TO THE STRUCTURE OF A "SOIL CRUMB," BUILT OF COLLOIDAL MATERIAL SURROUNDING A MINERAL NUCLEUS

dium, potassium, ammonium, and magnesium ions are those most commonly exchanged in this way. The fact that the exchange of cations between the soil and an added salt solution is practically instantaneous indicates that the exchangeable cations are held on the surface of the soil aggregates. If treatment of a soil with a salt solution be repeated several times over, practically all the bases originally present in an exchangeable state in the soil will be replaced by the cation of the salt solution used. From this it will be seen that "magnesium soils," "calcium soils," "hydrogen soils," and so on, may

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A RIVER WITH WATER CHARGED WITH SEDIMENT LIES AT THE BOTTOM OF THE GRAND CANYON OF THE COLORADO

be prepared, in each of which there will be only one kind of cation in the soil absorption complex.

Soils differ very greatly in their physical properties, depending upon the nature of the cations held thus. In ordinary fertile soils the calcium ion usually comprises nearly ninety per cent of the metallic cations adsorbed. When the whole adsorption complex of the soil is filled up with metallic cations the soil is "saturated"; if hydrogen ions are present in the adsorbed state the soil is "unsaturated." Normally most of the soils of the world,

and all of the fertile ones, are "unsaturated." "Unsaturation" in this sense, of course, does not mean acidity, for some unsaturated soils will be quite strongly alkaline in reaction.

Anions are not adsorbed by soils from salt solutions to any great extent. The phosphate ion appears to be tightly held by soils, after it is added to them in the form of fertilizer salts, but actually it is probably precipitated as a fairly insoluble calcium phosphate salt, the calcium cations that enter into this reaction largely coming from the soil base exchange complex. Other anions that are commonly added to the soil, such as carbonate, nitrate, sulfate, and chloride, are not adsorbed appreciably.

It will be realized that knowledge of the base exchange properties of soils explains much that would otherwise remain obscure. If we did not know that there is an exchange of cations in equivalent quantities much of the beneficial effect of fertilizer applications to soils could not be explained. It is believed on very strong evidence that plants obtain practically all of their mineral requirements from the soil as ions and necessarily in a water-soluble or weak carbonic acid-soluble state. From studies of the soil solution, which may be obtained in various ways, it is clearly evident that the calcium ion plays an outstandingly prominent part in plant nutrition.

The Soil Solution and Soil Acidity

The only practical justification of soil studies lies in the possibility of increasing soil fertility (or crop-yielding power) through application of the knowledge thus gained. It has been pointed out that plants can only take their mineral requirements as ions and these very largely from the soil solution. The modern conception of soil constituents that are essential to crop plants is that they exist in three levels of availability. It does not matter whether they finally are cations or anions, the general conception will apply. There is material: (1) at present totally unavailable, (2) in a semi-available condition, (3) immediately available for plant intake. By giving this some further consideration it may be made clearer. Let us consider among essential cations: calcium, magnesium, and potassium ions,and among essential anions: nitrate, sulfate, and phosphate ions. In the original soil minerals, existing unchanged in larger particles, we have at present totally unavailable material. In the absorption complexes at the surface of the colloidal aggregates present in all soils of any fertility (crop-producing power) we have cation material that is probably not immediately available, but that will become available for plant intake on receiving a slight "push." Inorganic materials in true solution, such as Ca^{++}, Mg^{++}, and K^{+} ions, are probably immediately available.

If we consider similarly the anions mentioned it will become apparent that these, in unfertilized soils, largely come from plant residues. The original plant material, unattacked by microörganisms (or the enzymes

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WITH WATER AND STONE AS TOOLS NATURE CARVED THIS PATH FOR THE ARKANSAS RIVER

Royal Gorge, Grand Canyon, Colorado.

that they secrete) is completely unavailable. When organic matter is attacked by microörganisms or their secretions it does not immediately go to simple ionic form, but it passes through a large number of intermediate forms, in which it may be considered as "semi-available" for plant use. It has been demonstrated as possible that some of the simpler amino compounds, for example, acetamide, may be utilized as such by plants (*15*). It is claimed by some (*16*) that organic phosphorus-containing molecules, such as phytin, are utilized by plants. Knudson (*17*) demonstrated that Canada field peas may take simple sugars into their systems unaltered.

Finally, the anions $SO_4^=$, NO_3^-, and $PO_4^{\equiv}$, which in soils are largely derived from organic sources, are themselves utilized directly by plants from the soil solution.

That which determines the fertility of any soil (that has enough moisture present to supply plant needs) is the balance existing between the different available soil constituents, and also the level at which the total concentration of salts in the soil solution is maintained. This equilibrium is termed by plant physiologists "the physiological balance." Apparently for great fertility in a soil there must be present a preponderance of calcium ions in the soil absorption complexes and in the soil solution. And there must be a relatively high concentration of nitrate ions present in the soil solution. This does not mean, however, that the presence of considerable quantities of phosphate, magnesium, potassium, and sulfate ions is not essential, not to mention other ions such as ferric, borate, manganous, and so on, which have been shown to be necessary in minute quantities for proper plant development.

The hydrogen ion appears as the villain in the piece. Although it is normally present in small excess over the hydroxyl ion even in the most fertile soils the hydrogen ion if present in any great concentration (say so as to give a pH value less than about 6.00) acts to prevent best soil fertility. Just how it does this is still very much of a disputed point. We know that soils in which there are high concentrations of hydrogen ions are nearly always deficient in available calcium and that they often contain soluble aluminum and iron salts. Neutral soils or slightly acid ones do not contain soluble iron and aluminum. It is believed by many workers that the ill effects on most crop plants of high hydrogen-ion concentration in the soil may directly be ascribed to the soluble iron and aluminum commonly present under this condition.

Soil Fertility and Lime

It has been pointed out previously that soils well supplied with strong bases are generally very fertile ones when there is sufficient moisture present. Calcium is by all odds the predominant strong base in the soil solution and in the base absorption complexes of all ordinary soils.

The most fertile soils in the world, whether they occur in warm or cold climates, are those well supplied with lime. For example, the rich agricultural country of southern Pennsylvania, the Hagerstown and Frederick sections of Maryland, the Shenandoah Valley of Virginia, the blue grass country of Kentucky, and some of the most fertile parts of Tennessee, all have soils derived from the same general formation of limestone rock. The weathering of ages in some cases has removed overlying layers of sandstone (which makes much less valuable soil material) and has exposed limestone strata which make soils rich in the great soil builder—calcium.

THE MIGHTY ETCHINGS OF EROSION, PARACHUTE CREEK, COLORADO

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In other parts of the world this is true also. In the Argentine pampas there are millions of acres of soils rich in lime. This exceedingly rich agricultural country owes its fertility to the magic element calcium. Similarly the fertile prairie lands of the American and Canadian west are rich in lime. Geologists say that a great shallow inland sea lay for ages over this central American plain. During the cretaceous period of the earth's history countless marine creatures died and their calcium-rich bones and shells settled to the oozy floor of the central North American sea. They have left a legacy of calcium-richness to the soils of today.

The champagne grape-growing districts of France, the Rhineland of Germany, the most fertile parts of Italy, the rich fenlands of midland England, all have soils which confirm the great value of lime. Lime richness is coupled with soil fertility.

Many go so far as to claim that well-limed soils produce feeds that mean strong-boned and healthy animals and consequently a strong and healthy human population. It is certain that the best forage crop for the feeding of cattle, that is known to man, will only thrive on well-limed soils. Alfalfa is rich in protein and in minerals and is termed by stock-feeders "the king of feeds."

Calcium is very intimately linked with life. Periodically in the newspapers one reads of scientists who have made statements that deficiencies in calcium metabolism are causal agencies in such human ailments as tuberculosis and cancer. Not only the mineral framework of men and animals (the bones) but also the blood needs calcium balance. When King George V of England was ill about twenty months ago, calcium was added to his bloodstream by a method perfected by a young American physiologist. Every one nowadays is acquainted with the marvelous effects of cod-liver oil and sunshine in promoting the health and happiness of mankind. Calcium ingested by rickety babies may not be built into bone as calcium phosphate, but by irradiation with ultra-violet rays in moderate amount, or by the addition of a little cod-liver oil to the diet, the bones of these rickety babies will firm up and become normal within a relatively short time. It has been shown (*18*) by endocrinologists that the efficient functioning of certain glands, for example, the parathyroid, is very closely linked with the calcium metabolism of animals.

The addition of lime to acid soils is a recognized method of increasing their fertility. Liming is practiced in all humid climate parts of the world in which agricultural science is known. While it may take many years of treatment to make fertile soils out of ones that are naturally lime deficient, yet cases are known in which this has been accomplished. One hundred and fifty years ago, in parts of Scotland, an old chronicler (*19*) tells of fields white with ground limestone applications, and notes the fact that heavy applications of lime (of 3 and 4 tons per acre) were made to soils not once but

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RIVERS ARE LARGELY "SOIL SOLUTION" AND SOIL COLLOIDAL MATTER
Ferry on "The Muddy Colorado" near Needles, California.

State Historical Society of North Dakota

TYPICAL ROLLING PRAIRIE FOUND WEST OF THE MISSOURI RIVER
This photograph was taken on the site of old Fort Lincoln which was located about four miles south of Mandan, North Dakota.

many times. Today many of the Scottish soils, which are not of limestone origin, are in excellent condition physically and chemically due to this treatment of a century and a half ago.

Plants are the chief source of calcium for animals. This is true whether the animal is marine or terrestrial, for plants are the basic food of fishes as well as of mammals. Flesh-eating animals eat those that live on plants. Energy-giving and flesh- and bone-building substances for animals all originate in the photosynthetic activities of plants. The source of calcium is the rocks of the world. In the majority of cases where there is relatively great concentration of calcium in rocks it is due to enormous accumulation in that place of the shells and bones of organisms that lived in past ages. Not only calcium is concentrated in this way but also phosphorus, for the bones of animals are essentially calcium phosphate. All the mineral constituents essential to living organisms originally come from rocks, or from soils which have arisen from the rocks. The sea, which is rich in soluble mineral salts, is the great evaporating dish for the soil and rock extracts of the world. The water which evaporates from the sea, and falls upon the land as rain or snow, runs off or leaches out and carries down with it still more solids in suspension and more salts in solution to the sea.

Agricultural Experiment Station, Bozeman, Montana

SCAB LAND TYPICAL OF THE DRY GRAZING AREA IN MONTANA

Agricultural Experiment Station, Bozeman, Montana

SOIL PROFILE OF VIRGIN PRAIRIE LAND IN FLATHEAD VALLEY, MONTANA

Fertilizers

During the last century there has arisen one of the world's great industries. Commercial fertilizers are applied to enrich the soil solution in essential constituents for crop plants. While other elements have been found valuable as fertilizers under some conditions it is for their content of available nitrogen, phosphorus, and potassium that most materials are applied as commercial fertilizers.

The fertilizer industry is essentially a chemical industry. Until the present century the problems of the commercial fertilizer manufacturer have been largely those of extraction from natural deposits, and of reactions, effected on a factory scale, between raw materials. In the early stages of the manufacture of superphosphate fertilizer, bones were the chief materials treated with sulfuric acid so that the more soluble and available calcium hydrogen phosphate salt could be produced. Early in the nineteenth century the great natural accumulations of caliche in Chile were first treated for recovery of Chilean nitrate of soda; later on, the natural deposits of tricalcium phosphate in the southern United States and in various other parts of the world were tapped as a source of raw material for the manufacture of superphosphate; and still later the vast "lagoon evaporation residues" of potassium-rich salts in Germany were attacked for recovery of potassium fertilizer salts. The great value of packing-house refuse as a source of fertilizer was recognized. The recovery of ammonia, as the fertilizer salt, ammonium sulfate, which is produced as a by-product in the destructive distillation of coal, was also developed.

Largely during the World War and since then the synthetic nitrogen fixation industry has arisen. Previous to 1914 and during war pressure, Haber and his co-workers developed an economically feasible method for fixation of atmospheric nitrogen, using purified water gas from the destructive distillation of brown coal, as a source of pure hydrogen gas, and nitrogen from the air. By a suitable combination of heat and pressure and the use of catalyst material, the nitrogen and hydrogen are wedded. Other methods of atmospheric nitrogen fixation have also been developed, notably the cyanamide process, and the various electrical methods. There is a bewildering array of synthetic nitrogen fertilizers on the market today, arising from the activities of chemists employed by the great corporations engaged in their manufacture.

What are the main functions in plant nutrition of the three principal elements about which the edifice of the commercial fertilizer industry is reared? Nitrogen is applied primarily to encourage vegetative growth. Without leaves and stem, fruit and seed formation in plants will not take place. Potassium is applied to the soil to give quality to crops. Potassium appears to encourage the synthesis and translocation of materials

within plants and also it increases their resistance to disease. Phosphate fertilizers encourage maturity. Seed and fruit formation are helped and root development promoted. It must never be lost sight of that the only reason for the use of commercial fertilizers is to increase the fertility of soils through enrichment of the soil solution or of the soil absorption complexes. This is literally a concentration of the desired elements in available form in the soil to which application is made.

Only by proper understanding of soils may their primary needs be appreciated and supplied. In many cases it is idle to apply commercial fertilizers until soil acidity has been modified by application of lime. In other cases no commercial fertilizers may at present be needed. In still other cases it will be the wisest practice to apply one, two, or all three of the so-called essential fertilizer elements. The salt which contains the fertilizer element determines its value to a considerable extent. For example, it is well known to practical farmers and fruit growers that the source of the nitrogen in the fertilizer materials that they buy is an all-important consideration to them.

Life in Soils

Charles Darwin (*20*) drew attention to the important part that earthworms play in soil fertility. The great value of these creatures in promoting desirable conditions in the soil is being recognized more fully with the passing of each decade. They mix the soil constituents thoroughly; they drain the soil and aerate it. In acid soils and in soils of low fertility earthworms are not found in any numbers. Here again calcium is known to play an essential part, for soils poor in calcium contain but small numbers of starved and stunted earthworms in comparison to more fertile soils.

There are literally millions of tiny invertebrate animals in every acre of soil. Insects, spiders, ticks, slugs, snails, centipedes, millipedes, and minute worms live in and on the soil. The numbers of these tiny animals are small, however, compared to the vast soil populations of microörganisms, plant and animal in nature. In every acre of fertile soil there are hundreds of pounds of living organisms present. Algae, fungi, actinomycetes, and bacteria may be considered as plants of microscopic size, while protozoa are microscopic animals. Millions of microörganisms exist in every gram of a fertile soil.

It is the life existing within the soil that enables it to function as the life layer of the world. The microörganisms derive energy and sustenance from the organic matter decomposed by the action of their secretions. The oxidations and reductions effected biologically in the soil are perhaps the most important of all reactions to living beings. If dead organic matter were not decomposed, in a few hundred years the surface of the world would be so encumbered with dead beings that there would be no room for the

living. Not only do microörganisms dispose of dead organic matter, but in so doing they split it up and release the locked up elemental matter. Matter thus released again becomes available for incorporation in living organisms. The fact of the repeated utilization of the materials forming the earth's crust by succeeding generations of living beings, over hundreds of millions of years, is driven home to any one who has made any study of rock strata. Each one of us is truly materially immortal, for the elemental stuff of which our temporary shell is made does not perish, but returns to Mother Earth. We may be sure that we too play our part in the cycle of matter.

Liming and fertilizing the soil in many cases promotes the development of beneficial microörganisms. The soil in such a case becomes a more efficient machine in its ceaseless production of energy and life-giving fertility constituents. The cycle of matter is a fascinating study. We know that if it were not for the life that it contains there could be no true soil; also we know that if soil did not exist the familiar forms of terrestrial life could not exist. It reminds one of the question, "Which came first, the hen or the egg?" In this instance the laws of probability indicate that the raw materials out of which life is fashioned were here before life itself, so the egg precedes the hen! The sea undoubtedly is the cradle of life on earth.

And now a nobler cycle swings into view. Through countless ages sediment from higher lands settles to the floor of a shallow sea. Then comes a time when the sea bed upheaves and becomes dry land. Geological evidence exists throughout the world to prove that this has happened in all continents not once but many times in the same region. It is only when under water that sedimentary rock strata form. The cycle is complete when the upheaved land again comes under the lash of climatic influences and erodes, sending down sediment in its rivers to another sea where new strata form.

True soils are completely dynamic in nature. Replete with life, they change from hour to hour. A seemingly unending succession of cycles of matter governs the nature of soils from age to age, and from minute to minute. Soils cannot be considered apart from the hydrosphere, for they, with the surface waters, form a mighty blanket of matter which contains the life of the earth.

* * * * *

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Writing with Water. Tannic acid reacts with ferric salts to produce a nearly black precipitate. This reaction, however, can only take place when the chemicals are dissolved in water. By writing with water on a paper over which the above chemicals have been spread, the effects described are obtained.—*The Science Classroom*

SYMMETRICAL AND ANTI-SYMMETRICAL HYDROGEN*

HERRICK L. JOHNSTON, THE OHIO STATE UNIVERSITY, COLUMBUS, OHIO

A striking feature in the spectrum of molecular hydrogen is the alternation in intensities which occurs in the rotation lines. One observes alternately weak and strong lines. The relative intensities of adjacent weak and strong lines are roughly one to three.

Mecke (*1*) pointed out that such an alternation usually appeared in the spectra of diatomic molecules whose atoms were alike. Heisenberg (*2*) and also Hund (*3*) treated the problem from a theoretical standpoint and showed, by the equations of the wave mechanics, that all homopolar molecules should exist in two forms due to differences that should exist in the nature of the binding between the atoms. One form, called symmetrical because associated with what is referred to in the language of wave mechanics as a "symmetrical eigenfunction," exists only in even rotation states. The other form, called anti-symmetrical because associated with an "anti-symmetrical eigenfunction," exists only in odd rotation states.

Hydrogen, they thus reasoned from a theoretical standpoint, should exist as a mixture of two varieties of molecules, differing in the manner in which the atoms are coupled. One form, symmetrical hydrogen, is responsible for the weak lines of the hydrogen spectrum, while the other form, anti-symmetrical hydrogen, is responsible for the strong lines. The one-to-three ratio of intensities is a measure of the relative numbers of molecules in these two states.

The two forms were held to be transformable into one another and to exist in a state of equilibrium which, on account of differences in their energies, should be dependent on temperature. By making use of the distances between the lines in the spectrum and of the approximate one-to-three ratio of intensities it is possible to make a quite accurate calculation of the ratio in which the two kinds of hydrogen molecule should exist at any temperature. At very high temperatures the proportion should be very nearly equal to that at room temperature and approach exactly 75% anti-symmetrical to 25% symmetrical at infinite temperature, in the limit. At the temperature of liquid air the proportions of the two should be nearly equal and at liquid hydrogen temperature 99.7% should exist in the symmetrical form and only 0.3% in the anti-symmetrical. So, as the temperature is lowered the anti-symmetrical molecules are converted to symmetrical. With a return to higher temperatures the anti-symmetrical form is restored.

It was originally supposed that approach to equilibrium between the forms would be rapid at any temperature. But Dennison (*4*) was the first

* An address given before the Physical Science Section of the Tenth Ohio State Educational Conference, held in Columbus, April 3, 4, and 5, 1930; and printed in the *Proceedings*.

to present grounds for the belief that this latter supposition was apparently not true. It has long been a problem to reconcile the experimental values for the specific heat of hydrogen gas with the theoretical values which, it seemed, should be subject to rather accurate calculation. It was always assumed, before Dennison, that one was dealing with a gas in thermal equilibrium. Dennison suggested that the transformation between symmetrical and anti-symmetrical states did not occur immediately and hence that the experimental values were obtained with non-equilibrium mixtures of the two varieties. He verified his suggestion by making a calculation of the specific heats to be expected for hydrogen gas in which the proportion of symmetrical to anti-symmetrical remained unchanged from that at room temperature and he obtained values in agreement with the experimental data.

Up to this point the evidence in favor of the existence of symmetrical and anti-symmetrical hydrogen was of a theoretical nature. The first direct experimental evidence for the existence of two kinds of hydrogen and their slow rate of transformation into one another was made public in a paper by Giauque and Johnston (*5*). In this paper the authors presented the results of experiments which showed that hydrogen kept under pressure at the temperature of liquid air for a period of six months possessed a lower melting point and a lower vapor pressure at its melting point than did ordinary hydrogen. The melting point of the special hydrogen was 0.04° lower and its vapor pressure at the melting point 0.4 of a millimeter lower than that of ordinary hydrogen. The limits of error were about 0.01° in the temperature measurement and something less than 0.1 of 1 millimeter in the pressure measurement. This was regarded as evidence for the existence of two forms of hydrogen and of their slow rate of transformation into one another.

Several days later verification from quite a different experimental angle was produced. McLennan and McLeod (*6*) at the University of Toronto made the discovery that a ray of monochromatic light passed through liquid hydrogen emerges as polychromatic light. In addition to the strong spectral line corresponding to the wave-length of the incident beam were two fainter lines on the long wave-length side. Quantitatively, the positions of the new lines corresponded, respectively, to absorption between the number one and number three rotation levels of hydrogen and between the zero and number two levels. This is known as the Raman effect and is well known for other liquids and gases. But the significant thing observed by McLennan and McLeod was the fact that the one-to-three line, which according to theory is associated with antisymmetrical hydrogen molecules, and which was initially the stronger of the two new lines, gradually faded while the zero-to-two line, associated with symmetrical hydrogen, became more intense. This, of course, was properly interpreted as evi-

dence for the slow transformation of one form of hydrogen to another.

A few weeks later Bonhoeffer and Harteck (7), in the first of several papers which reported results of their very extensive investigations, presented evidence, obtained by a still different experimental method, for the existence of the two forms of hydrogen. Further, they obtained information on the normal rate of the transformation between the two types at various temperatures; on conditions which influence the rate and on the existence of catalysts which within a few minutes bring about the transformation which normally would require weeks or months to attain equilibrium. Thus they found that, at the temperature of liquid hydrogen, charcoal was an effective catalyst in converting the 75% anti-symmetrical mixture existing at room temperature to the 99.7% symmetrical mixture stable at the lower temperature. Also at the temperature of liquid air charcoal behaves as an effective catalyst in producing the roughly 50% mixture of the varieties. The reconversion to the 75% anti-symmetrical mixture at room temperature is best brought about by platinum or palladium black as catalysts. They examined a number of other catalysts and found that other conditions, such as pressure and liquefaction, were effective in producing more rapid approach to equilibrium.

Experimentally, they were able to detect the transformation very quickly and very simply by measuring the heat conductivity of the gas for, as they showed conclusively, the symmetrical variety is the better heat conductor of the two forms, at least in the neighborhood of liquid air temperatures. A change in the proportion of the two forms present in the mixture thus produces a difference in the heat conductivity of the gas.

With the means of preparing large quantities of practically pure symmetrical hydrogen, they were able to make extensive studies of the properties of symmetrical hydrogen as distinct from the usual mixture rich in the anti-symmetrical variety. Thus they found the melting point of symmetrical hydrogen to be 0.09° lower than that of ordinary hydrogen and the vapor pressure at the melting point 0.9 of a millimeter lower than that of ordinary hydrogen. These figures are in complete agreement with the 0.04° degree and 0.4 millimeter low values obtained by Giauque and Johnston for hydrogen stored at liquid air temperature, which is a half and half mixture of the two varieties.

Bonhoeffer and Harteck adopted a new nomenclature, para- and ortho-hydrogen, to replace the older nomenclature, symmetrical and anti-symmetrical, but it is doubtful if such a substitution is advisable in view of other usages associated with the terms para and ortho.

We shall attempt to demonstrate the existence of the two forms of hydrogen by means of the heat conductivity method of Bonhoeffer and

Harteck. As the conductivity vessel, we have a cylindrical glass bulb with sealed-in electrodes connected by about six inches of very fine platinum wire. At room temperature this wire has a resistance of about 175 ohms and at liquid air temperature a resistance of about 50 ohms with intermediate resistances at intermediate temperatures. The resistance of the wire thus serves as a thermometer to measure its temperature. The bulb is surrounded with liquid air. First we will admit into the bulb ordinary hydrogen, at a pressure of about four centimeters, from this cylinder of commercial hydrogen. And now we will heat the wire by applying a constant voltage across its terminals. By means of this Wheatstone bridge we measure the resistance of the wire. This we now find to be about 126 ohms. This corresponds to a temperature some hundred degrees above that of liquid air. However, the resistance remains constant due to the balance reached between the heat generated in the wire and the heat conducted away by the hydrogen to the walls of the vessel. Next we will pump out this ordinary hydrogen and refill to the same pressure with hydrogen which has been standing for some time in contact with charcoal in this bulb filled with liquid air. You observe the deflection produced on the galvanometer. We now rebalance the bridge and observe that the resistance of the heated wire is now about 123 ohms. This corresponds to a cooler wire and means that the hydrogen now in the vessel is carrying the heat away from the wire more rapidly than did the ordinary hydrogen. We will next pump out this hydrogen also and refill the bulb with hydrogen again from the supply in contact with the cold charcoal but passed through this tube over a small quantity of platinum black. You observe that the galvanometer is deflected back in the original direction. The bridge reading corresponds again to the approximately 126 ohms obtained with the ordinary 75–25% mixture of the gas.

The question may arise in your minds as to whether symmetrical hydrogen may differ chemically from ordinary hydrogen. The answer is "yes," although only to a slight extent. It is to be expected that the voltage of the hydrogen electrode with symmetrical hydrogen should differ measurably from the voltage produced with usual hydrogen. Experimentally this difference escapes detection, however, since the platinum present in the electrode catalyzes the transformation of symmetrical hydrogen to the ordinary variety. It might also be expected that the reducing action of hydrogen rich in the symmetrical variety should be slightly greater than that of ordinary hydrogen.

You may inquire as to the physical difference in the two forms of hydrogen. The difference is probably due to differences in the direction of spin of the two hydrogen nuclei which are joined to make the molecule. We know from other sorts of data that in a great many atoms the protons are

spinning like little tops. It is probable that in symmetrical hydrogen the two hydrogen nuclei are spinning in opposite directions, clockwise and counter-clockwise, we might say; while in anti-symmetrical hydrogen they both spin in the same direction.

You wonder if other molecules might also show this mixture of varieties. The answer is "yes." In fact the alternation in intensities of the rotation lines of the spectrum is found in chlorine as in hydrogen, although the relative intensities are somewhat different. It is probable that chlorine exists in four forms—two pairs of varieties: the members of each pair in rapid equilibrium with one another, the members of opposite pairs not coming rapidly to equilibrium. Fluorine probably exists in the same types of varieties as does chlorine. In nitrogen there are probably three varieties of molecules. In these latter cases, however, we cannot expect to obtain the same sort of experimental evidence for the existence of different varieties since calculation shows that in order to get appreciable variation in the ratios of the various varieties from those existing at room temperature one would have to cool the gases to lower temperatures than for hydrogen. Experimentally, those gases cease to be gases at temperatures considerably higher than for hydrogen.

Other common molecules are known to exist as mixtures of different varieties—varieties as truly distinct as those illustrated in the hydrogen case—due not to the manner in which spinning protons are coupled but to the manner in which spinning electrons are coupled. Approach to equilibrium in these cases is ordinarily very rapid, however. Thus ordinary oxygen gas composed of two like atoms of mass 16 exists as a mixture of three different varieties which are present in different proportions at room temperature (*8*). In the case of nitric oxide we have four different varieties as a result of electron spin and it is probable that each of these exists in three different forms due to the presence of spin in the nitrogen nucleus. So that, in all, probably twelve distinct varieties of this common gas are present. In general, it is safe to predict that for a great many molecules familiar to us in chemistry there must exist a mixture of several such varieties.

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FIFTY YEARS OF CHEMISTRY TEACHING IN SOUTHERN COLLEGES*

J. F. Sellers, Oglethorpe University, Georgia

The teaching and training of students for scientific professions and for scientific investigation is as vital and important to the welfare of the country as the making of scientific discoveries.

Frederick Soddy

The law of progress by catastrophe has directed our manner of recording history and controlled our method of interpreting science. Revolutions have set up historic milestones in dividing the eras of the human race and cataclysms have established geologic shorelines in separating the ages of the ancient earth. The Civil War with its aftermath of reconstruction closed the tragic era and created a new epoch in southern civilization. Surviving this crisis the South has not sold its birthright of Cavalier culture, but has gained in national consciousness and integrity. Under the impulse of shifting ideals the South has advanced in industry, culture, and wealth. Hence it is fitting that this session of the American Chemical Society, in reviewing the half century of southern progress, should receive an inventory of the status of chemical education in the South. For this reason the secretary of the Division of Chemical Education has requested a census of chemistry teaching in southern colleges during the closing epoch.

As men count years, a half century is a generation of human life, and the span is fixed by the counter revolutions of birth and death. The half century of chemistry teaching in the South seems a long range of years, while much water has passed over the mill. But the epoch is only an imaginary unit of time and differs from other units more in degree than in kind. Many of the men who taught the science fifty years ago, worn by the heat and burden of the race, have relayed the torch to younger and stronger hands. But the science of chemistry has changed more fundamentally than its teachers, and the teaching has advanced with the expanding science. In considering the progress of chemistry teaching in southern colleges during the past half century, we are to recount several factors which have developed the product.

First, there had come to the New South by inheritance a program of education not inferior in quality to that produced in the North. In reviewing the history of higher education in the South we are directed to an institution which had developed a type of education in advance of the time, namely, the University of Virginia. When the University was organized in 1826 there was no institution of higher learning in America comparable to it in purpose and in practice. Harvard and Yale were the tardy growths of an unfavorable colonial environment, but the University

* Read before the Division of Chemical Education at the Atlanta Meeting of the American Chemical Society, April, 1930.

Photo by Holsinger

THE COBB CHEMICAL LABORATORY, ERECTED IN 1917, UNIVERSITY OF VIRGINIA, UNIVERSITY, VIRGINIA

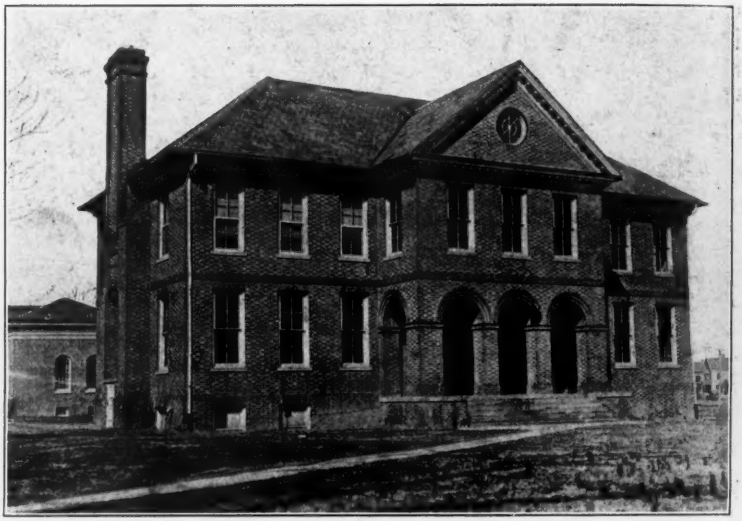
of Virginia was the mature expression of Thomas Jefferson, confirmed by the thought and practice of the best minds of Europe. The University sprang from the brain of Jefferson as Minerva from the head of Jupiter, full-armed and full-orbed. Jefferson in his versatile knowledge sought to democratize learning and culture as he had espoused the doctrine of democracy in government. To this end he gave equal rank to the ancient classics, the social humanities, and the physical sciences. His faculty of nine men included three professors of the sciences, and the scientific equipment of the university consisted of the best apparatus to be obtained in Europe.

Without detailing their contributions we mention some of the distinguished chemists of the University of Virginia, either as teachers or as students, during its early and middle periods: J. P. Emmet, the first professor of chemistry, J. Lawrence Smith, J. W. Mallet, R. W. Jones, Harry C. White, Charles E. Wait, F. P. Venable, and F. P. Dunnington. Opportunity permits only a brief reference to the work of Dr. Mallet who taught and encouraged many of us still active in service. Dr. Mallet was not only a charming teacher, but he ranks among the great American chemists, probably the greatest in this country in his time. His work in confirming the atomic weights of lithium, aluminum, and gold places him with Stas in knowledge and accuracy in that field of chemistry. During the Civil War he was chief chemist for the Ordnance Department of the Confederate States, and Dr. Charles E. Monroe of the Bureau of

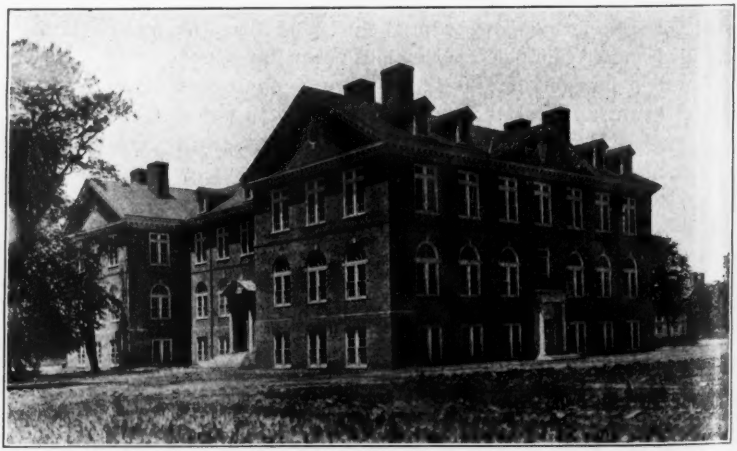
NEW CHEMISTRY BUILDING, UNIVERSITY OF RICHMOND, RICHMOND, VIRGINIA

Mines said recently that the early success of the Confederates was largely due to the superior gunpowder made by Dr. Mallet. He published more than one hundred pamphlets on various chemical subjects, many of which are found in foreign literature. We have emphasized the University of Virginia because it was the prototype of the colleges of the Old South, but, though still potent, its leadership has shifted in the New South to another institution created primarily for graduate research, namely, The Johns Hopkins University.

Second, the change of the South from the poverty and chaos of the Reconstruction Period to its present status of social and industrial consciousness has reënforced its culture and economic progress. There have been three Souths: the Old South with its tradition, the Conquered South with its humiliation, the New South with its aspiration. The Old South with its potential leadership in government and wealth developed a system of education not inferior to that of other sections of the nation. But the Civil War destroyed the educational system of the Old South. Many colleges replenished the thin gray lines of Lee and Jackson with their faculties and students, converted their endowments into Confederate bonds and their buildings into barracks and hospitals. Then, after Appomattox, began the tragic era of the Conquered South with its young manhood decimated, its political hopes shattered, its economic

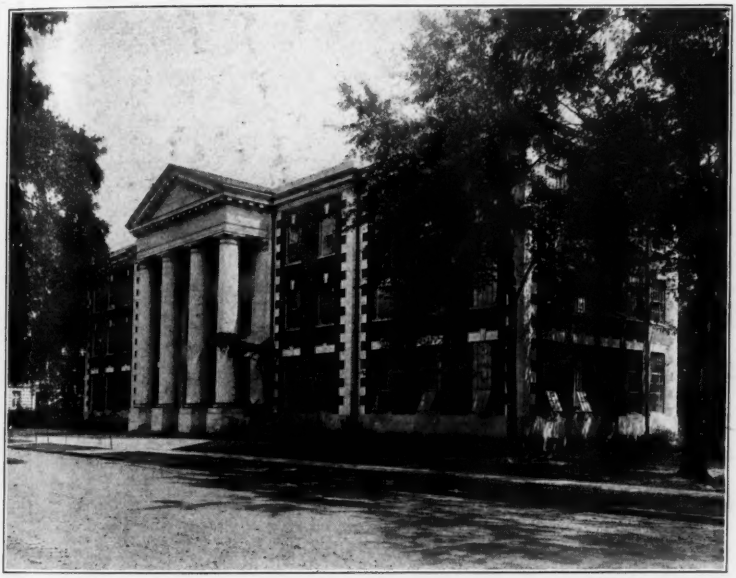


Ewell Building, Erected in 1905 and Used until 1920 for All Classes in Chemistry, Physics, and Biology.



The William Barton Rogers Science Hall, Erected in 1927, in Honor of William Barton Rogers, Graduate of and Professor in the College and Founder of the Massachusetts Institute of Technology.

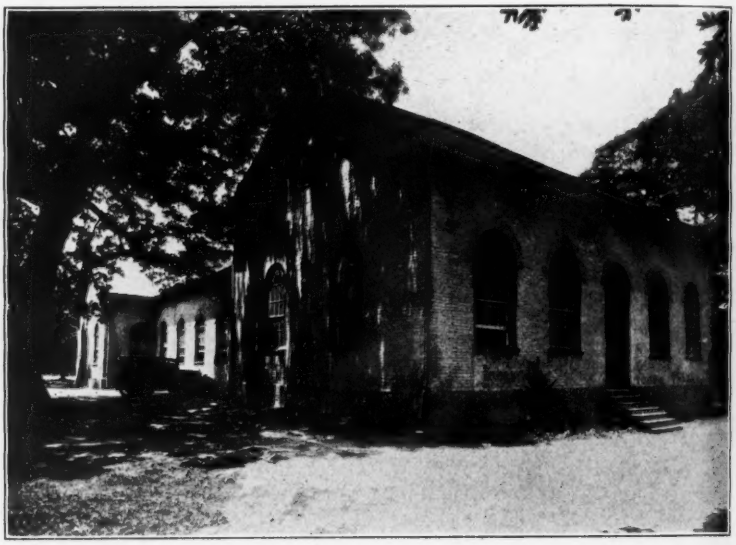
SCIENCE LABORATORIES OF THE COLLEGE OF WILLIAM AND MARY, WILLIAMSBURG, VIRGINIA



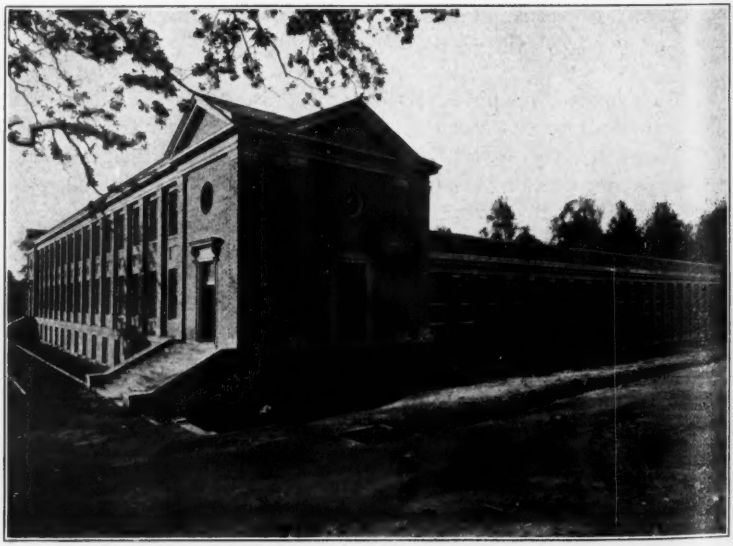
CHEMISTRY BUILDING, UNIVERSITY OF ALABAMA, UNIVERSITY, ALABAMA
This laboratory was built in 1917.

systems abandoned, its physical substance destroyed. The white men of the Conquered South became primal in their instincts for the preservation of their kind, and resorted to the primitive weapons of their ancestral clans to fight the ravening wolves from their doors, and to drive still more savage men from their hearthstones. All civilizing forces of the South were atrophied, and many colleges succumbed in the backwash of war. Other colleges which marked time during the shock of war and the stress of reconstruction eventually caught the step again. But the nation grew weary of fraternal hatred and strife, and the patriotic men of the North joined with the patriotic men of the South in creating and developing the New South.

Third, the progress of chemistry through discoveries of new energy and new matter has gaged the measure of its teaching. The philosophic doctrine of the unity of matter and energy extends to the relations among all the sciences of the physical world. In recognizing the interdependence of the major sciences of biology, chemistry, and physics, the modern trend is to emphasize the chemical divisions of physical chemistry and biological chemistry. As applied sciences, physical chemistry reënforces the principles of engineering, and biological chemistry interprets the



Chemistry Building, Erected in 1875.



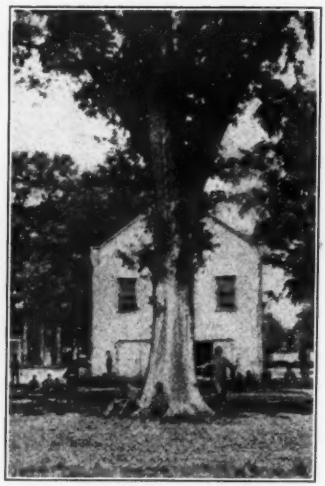
Venable Hall, Erected in 1925.

CHEMICAL LABORATORIES OF THE UNIVERSITY OF NORTH CAROLINA,
CHAPEL HILL, N. C.

CHEMISTRY BUILDING, UNIVERSITY OF MISSISSIPPI, UNIVERSITY, MISSISSIPPI
This building was built during 1922-23, and was occupied in the fall of 1923.

theories of medicine. The other divisions of general chemistry, organic and inorganic, possibly have reached a stage of overproduction in their discoveries and syntheses, and are now waiting for the consumption of their surplus.

Fourth, diversification of the industries of the South from an agricultural section to include the fabrication of its potential raw materials from its mines, forests, and fields has been a large factor in the progress of chemistry teaching in southern colleges. The major manufacturing industries in the South are of steel, cotton products, tobacco, sugar, petroleum, fertilizers, naval stores, ceramics, and so forth. All are creations of the art and the science of the chemist, and their development has fundamentally influenced the growth and teaching of chemistry in the South.



CHEMISTRY BUILDING, LOUISIANA STATE UNIVERSITY, BATON ROUGE, LOUISIANA

This laboratory, erected in 1893, occupying an area of 5000 square feet.

Fifth, progress of the social sciences during this century has introduced a new factor in culture and education. During the early Victorian era the ancient classics dominated the curricula of American colleges. Science was the menial servant, the Cinderella of the favored older sisters, the classic humanities. But at the close of the era the discoveries of science created a better manner of living and revealed a saner method of thinking. The Malthusian doctrine no longer disturbs mankind, for as men multiply they increase in knowledge and in wealth. Science reveals day by day more mysteries than the philosophies of men have ever dreamed of. As science has eliminated the barriers of time and space, all men everywhere have become neighbors. This contact has created new expressions of human thought and endeavor, the social sciences. These are now sharing the claims of the physical sciences in our college systems. That the physical sciences will decline like the ancient classics there is small fear, for as long as there are undiscovered laws and hidden treasures of the physical world to reveal there will be abundant service for the physical sciences to perform.

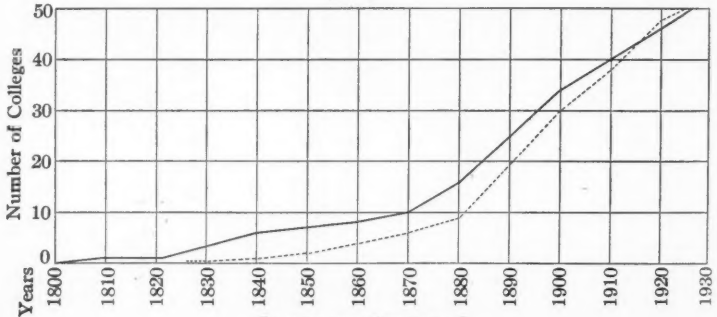
This brings us to a review of the responses to a questionnaire recently directed to sixty colleges of the South. Five colleges failed to reply, and

CHEMISTRY BUILDING, LOUISIANA STATE UNIVERSITY AND AGRICULTURAL AND MECHANICAL COLLEGE, BATON ROUGE, LOUISIANA
This building, erected in 1929, occupies an area of 80,000 square feet.

five others returned answers so inconclusive that the report is developed from fifty representative state institutions, denominational colleges, and private foundations.

I. Give the approximate year in which your institution established (*a*) *a separate department of chemistry, and* (*b*) *a student laboratory course for elementary general chemistry.*

The answers were not so informing as might be desired, for the reason that the meager records of many colleges permitted only approximations by the respondents. From the replies to (*a*) there were the extremes of the years 1799 to 1926. The average would be of less value than the observation that in the South eight colleges established separate departments of chemistry before the Civil War; eight, during the Reconstruction Period; and thirty-four, or sixty-eight per cent, during the past fifty



GRAPHS FOR QUESTION I

(*a*) ———— (*b*) - - - - - -

years. The replies to (*b*) cover the years 1826 to 1926, and suggest the second observation, that in the South only four colleges established elementary laboratory instruction in chemistry before the Civil War; five, during the Reconstruction Period; and forty-one, or eighty-three per cent, during the last half century. Chemical laboratories for individual experimentation by students date their origin to the founding of the famous laboratory by Liebig at Giessen in 1824. Before this, Liebig tells us he had to leave Germany for Paris to apply to Gay-Lussac for the privilege of working in his private laboratory. Wöhler had a like experience in working with Berzelius in his laboratory in Stockholm. Wöhler gives a humanizing description of his keen expectation of seeing the great laboratory in which Berzelius had determined so many atomic weights with such accurate skill, only to find two small rooms serving as a combined laboratory and home for the great chemist. As general factotum the severe old Anna

University Hall, Erected in 1880 and Used for Science Classes.

Furman Hall, Built in 1906 and in Which Chemistry Classes Are Held.

SCIENCE LABORATORIES OF VANDERBILT UNIVERSITY, NASHVILLE, TENNESSEE

cleaned the apparatus and prepared the meals for the master. In all the literature there appears no word of commendation for the faithful Anna, the household drudge, with scant praise for her pains. Who knows but that the confirmation of the atomic theory and the creation of the dualistic doctrine of chemical compounds by Berzelius were in some measure due to the clean alembics and the heated charcoal furnace which Anna had kept ready for the temperamental genius! Quoting from a paper (*1*) prepared by the writer for the New Orleans meeting of the American Chemical Society twenty-five years ago, it is interesting to recall the testimony of three well-known and honored teachers of that period now receiving their abundant reward. Dr. Caldwell of Tulane: "Some laboratory work is advisable, but laboratory work is often overdone." Dr. White of the University of Georgia: "We do not invariably give laboratory work." Dr. Wait of the University of Tennessee: "We do not require laboratory work." It is possible that even now we have made a fetish of laboratory work. At that time Harvard, Yale, Princeton, and Virginia gave excellent courses in chemistry without laboratory, but illustrated with brilliant lecture experiments. In the evolution of chemistry teaching, we are facing the same problem in which language teaching provoked a wordy wrangle among the German universities fifty years ago. Leipzig placed grammar before literature; Berlin placed literature before grammar.

II. Give a list of different courses in chemistry offered in your curriculum.

The record does not include graduate work in chemistry. Of the fifty colleges concerned, twenty-five reported three to six courses in chemistry; fifteen, seven to twelve courses; and ten, thirteen to twenty courses. As would be expected, all colleges offer elementary instruction in general, analytical, and organic chemistry; thirty-five, in physical chemistry; and twenty, in physiological chemistry. The other courses given are those which develop the technic for which certain colleges were established. There are more southern colleges offering technical work than was expected. Thirty of the list give technical instruction in some form, to apply to local demands and natural supplies. In evidence of this, all colleges receiving the Morrill fund specialize in the control of fertilizers, soils, and foods. The Louisiana colleges publish courses in sugar chemistry; those in Alabama, in iron and coal chemistry; those in Georgia, in cement and ceramic chemistry; those in Texas, in petroleum and gas chemistry. This is both pedagogical and profitable. While the study of chemistry should not be sidetracked for technical purposes too soon, practical application is helpful in reënforcing theoretical training.

III. Give (a) approximately the last year your institution had only one teacher of chemistry, and (b) the present number of your teaching staff.

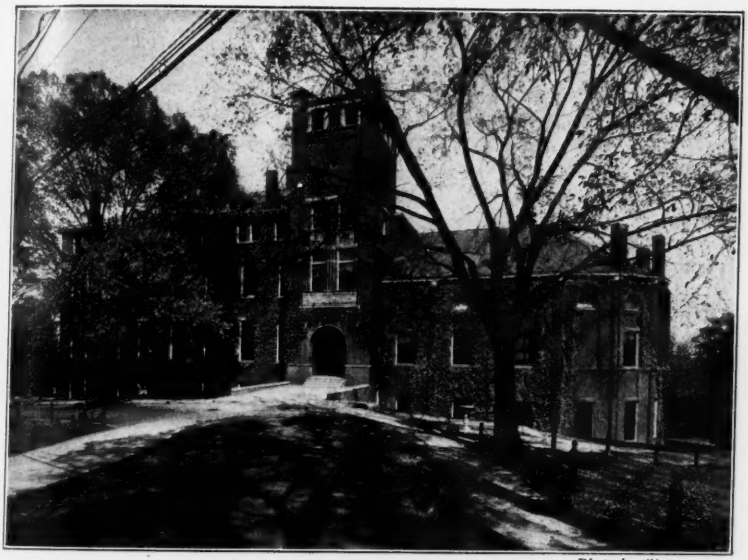


Photo by Thompson

Science Hall, Erected in 1891, and Now Used for Freshman Chemistry Students.

Photo by Thompson

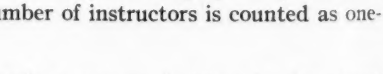
New Chemistry Building, Erected in 1929. End of Science Hall on Right.
UNIVERSITY OF TENNESSEE, KNOXVILLE, TENNESSEE

GRAPH FOR QUESTION III (*a*)

(*a*) Two of the colleges surveyed were organized each with more than one chemistry teacher and five others continue to the present, each with only one teacher of chemistry. Of the remaining forty-three colleges which began with one chemistry teacher, three of them increased their chemistry staffs before the Civil War; six, during the Reconstruction Period; and thirty-four, during the closing half-century. Through nine decades from 1820 to 1910 the curve ascends normally to twenty-two. Then it abruptly rises on the axis of ordinates to thirty-nine during the tenth decade, and again continues its normal increase of six during the last decade. If we may judge the progress of chemistry teaching in southern colleges by the arithmetical increase of the number of chemistry teachers, the two decades beginning with 1910 were epoch-making, for more colleges increased their teaching forces in that time than during all the preceding decades combined. (*b*) Of seventeen colleges each has two chemistry teachers, and of the next larger number, nine colleges, each has six chemistry teachers. The average is increased by the large number of technical schools that emphasize chemistry and employ many assistant professors and instructors. The number of instructors is counted as one-half in recording the averages.

IV. (*a*) *Does your institution maintain a separate building for chemistry? If so,* (*b*) *please give the approximate date when this arrangement began.*

In this general question the responses to (*a*) and (*b*) may be consolidated into one record. Separate chemistry buildings have come altogether within the past sixty years, and of the twenty-nine now existent, twenty have been erected during the present century. Judging by this rate of increase we may expect that practically all southern colleges will have chemistry buildings by the end of the present decade. Though only about half of the southern colleges possess chemistry buildings, the progress of

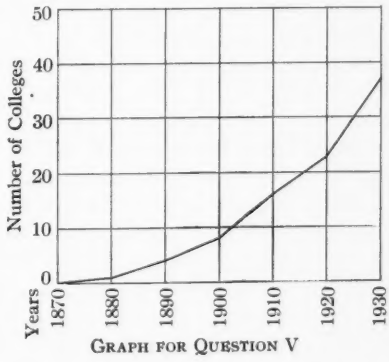


GRAPH FOR QUESTION IV

chemistry teaching in this section is not to be measured by the number of such buildings, for the record shows that there are six other colleges with science buildings, and still others with liberal spaces provided for the subject. There is danger of over-emphasis of elaborate apparatus, spacious buildings, and liberal teaching staffs. Lest we forget, we should recall the classic work of Davy and Faraday in the back room of the Royal Institution, and the discoveries of Berzelius and Wöhler in the modest apartment in Stockholm.

V. (*a*) *Does your institution maintain a separate departmental chemical library? If so,* (*b*) *please give the approximate date when this plan was established.*

As in question IV, the responses to (*a*) and (*b*) may be consolidated into the same record. Departmental chemical libraries are of more recent vogue than separate chemistry buildings. All the thirty-seven such libraries in southern colleges, excepting eight were established during the present century. The report on libraries is even more encouraging than that on buildings. It is possible to teach chemistry in improvised or borrowed buildings, but books are as essential to sound teaching as are apparatus and teachers. Library training should begin with laboratory exercises, and as the student advances in his chemical education he should read the literature in books and journals, and learn the technic of finding references in the library. Dr. Alfred Scott of the University of Georgia has enhanced the service of the departmental chemical libraries of this state by applying the practice of circulation among them. He has cataloged the chemical reference literature in the college libraries in Georgia with the purpose of supplying to each college the literature which it may not possess, but which may be obtained from other college libraries in the state. Dr. J. E. Mills of the National Research Council has conducted a survey of departmental chemical libraries in the South, and will make an authoritative report on the subject.*



GRAPH FOR QUESTION V

VI. At present only a limited number of freshmen offer high-school chemistry for college entrance. (*a*) *In your first-year course do you prescribe high-school*

* See, October, 1930, the forthcoming issue of the JOURNAL OF CHEMICAL EDUCATION.

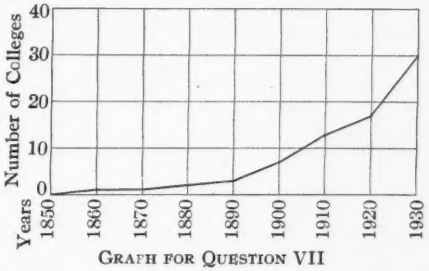
chemistry? If not, (b) have you found the high-school study of chemistry of material advantage in conducting your first course?

The subdivisions of this question, (*a*) and (*b*), are grouped as in the two preceding questions into one answer. It was found that only three colleges in the South prescribe high-school chemistry for the first-year college chemistry, but provide separate courses for students with or without high-school preparation; and that twenty-five colleges favor high-school chemistry; twenty disapprove; and five are doubtful. This virtually unanimous vote against requiring high-school chemistry for beginning the subject in college suggests three reasons: first, the large numbers of students who do not elect chemistry in the high school should not be deprived of the subject in college; second, chemistry as taught in the high school is too general or superficial for college entrance; third, many high schools teach chemistry in the wrong way, leaving the colleges to undo the wrong. Perhaps a majority of the colleges do not make these discriminations, but on general principles consider the high-school prescription as impracticable. This question is similar to one asked in the questionnaire twenty-five years ago, namely, "Should chemistry be taught in preparatory schools?" The object in asking this question was to secure some justification of the opinion of the Committee on Chemistry Entrance Examinations for the Association of Colleges and Secondary Schools of the Southern States. At that time the committee was composed of Francis P. Venable of the University of North Carolina, Cameron Piggott of the University of the South, and the writer, then of Mercer University. The majority of the committee were opposed to the study of chemistry in preparatory schools, but requested that this referendum of the colleges be taken before the report should be made. Of the forty colleges voting, twenty approved of preparatory chemistry; fifteen opposed; and five were inconclusive. At that time the colleges differed with the committee, but the current has shifted slightly in the committee's favor.

VII. Give approximately the year in which your institution first conducted graduate research courses in chemistry.

Of the thirty institutions now offering graduate courses, only one began this work before the Civil War; two, within the period from 1870 to 1890; fourteen, within the period from 1890 to 1920; and thirteen, within the last decade. Comparing this report with that made twenty-five years ago it is observed that several smaller colleges have abandoned their graduate courses and are laying emphasis on undergraduate work. Another helpful development learned from this investigation is the corresponding decrease in the number of southern colleges offering Ph.D. degrees. The smaller number reveals a growing desire of southern colleges to attempt that kind of work which they are best fitted to undertake. Many

have pretended to offer courses for which they were inadequately equipped. The cause is less of vanity or dishonesty than of history. Before the Civil War there were many well-equipped church and state institutions which, measured by erstwhile standards, were legitimately called universities. Then these institutions became impoverished by war and were no longer universities. But in many instances the titles carried with them grants and franchises, making it impossible to assume more appropriate names, though the governing authorities of the so-called universities would prefer that their institutions be named colleges, for obvious reasons. Furthermore, some institutions which enjoyed merited reputations before the Civil War have tried to justify their pretentions by indulging in the hope that they might come into their own again.



GRAPH FOR QUESTION VII

VIII. Give the number of (a) research contributions published by your chemistry department, (b) books on chemistry written by your faculty, and (c) industries in your state promoted by your institution.

The responses to this question are difficult to tabulate, as a majority were negative and the affirmative answers were varied and indefinite. A systematic treatment of the subject would develop an ambitious thesis for an address. For this reason only a casual comment is made on the meager information obtained from the questionnaire. Eighteen colleges report research contributions, ranging from two to four hundred and two, and a major part of the research was made by five institutions offering the Ph.D. degree. Thus we may infer that the greater portion of the research was done by graduate students in preparation for their degrees. As regards textbooks, southern colleges are somewhat behind in this form of authorship. Only fifty-one books on chemical subjects were reported from the colleges. As to industries advanced by the colleges, their authorities were unable to make definite reply. Twenty-five professors reported that their colleges had either developed or assisted in promoting industries in their states. These were concerned with virtually all the agriculture, mining, manufacture, and commerce of the South.

IX. (a) Do you offer fellowships in chemistry? If so, (b) please give the approximate year in which these fellowships were established, and the number now available.

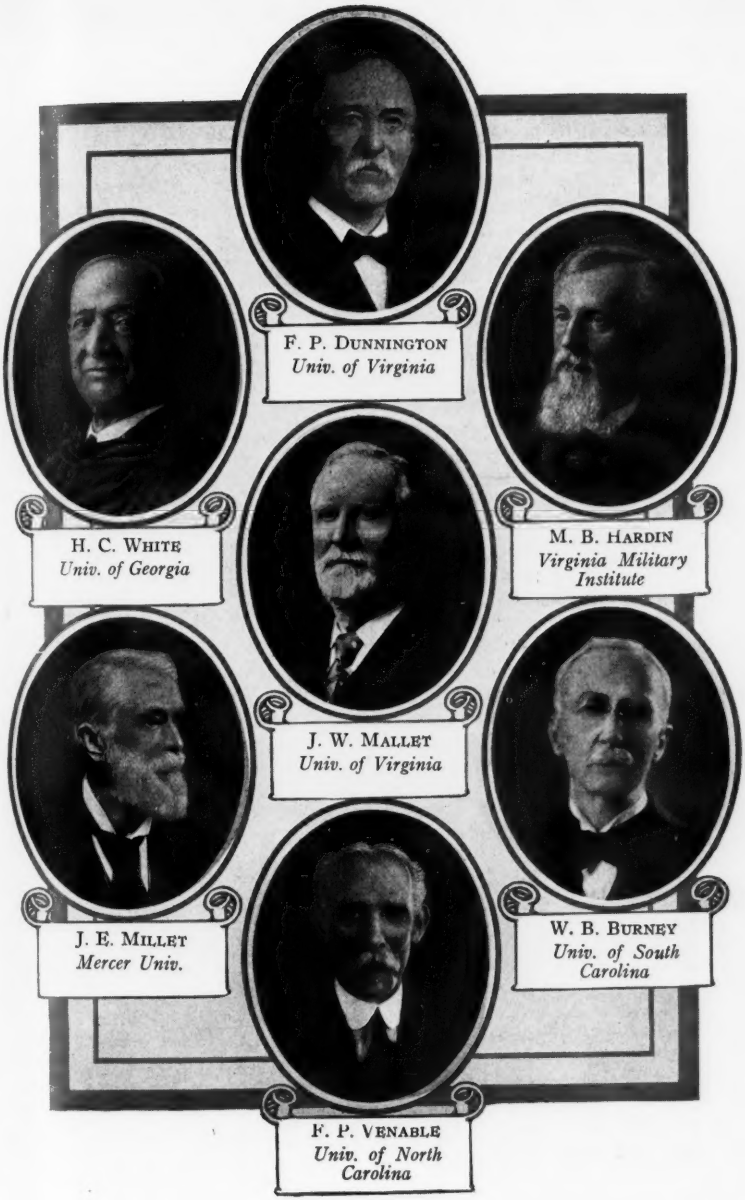
Twenty-nine southern colleges offer one hundred and sixty-two fellowships in chemistry, from one to twenty-eight in each. This larger number of fellowships seems to be the largest maintained by any institution in America. The report does not show whether any or all from the various colleges are teaching fellowships. The presumption is that only a few fellowships prescribe teaching, whereas a larger number require laboratory supervision and care of apparatus. The significance of the rapid growth of this form of assistance and preferment given to students is the increased service to applied chemistry in the pursuit of medicine, engineering, and commerce, and to pure chemistry in its aid to research in all branches of the science. Maintenance of fellowships accomplishes the reciprocal purpose of supplying to the colleges a service which the trained faculty have not the time and the untrained employees have not the ability to perform, and of giving to advanced students experience needed in their chemical education.

X. Give the names of teachers of chemistry who served or have served for thirty years or longer in your institution, or others.

Mankind has come up from the night of ignorance and superstition neither through the favor of environment nor by the mechanics of devices. Civilization is the prime product of a chosen remnant of the race who have sacrificed for the getting of wisdom and suffered for the gaining of knowledge. Though Socrates taught wisdom in the market place of Athens, and Plato dispensed understanding in the grove of Academus, these made "the glory that was Greece." Neither generous equipments nor princely foundations, but the consecrated teachers of the South have builded its colleges and fostered its science. Science may be revealed in retorts, and knowledge gained in books, but love of science and desire for knowledge are transmitted by personal contact. The progress of chemistry in this epoch of the South has been advanced by the pioneer teachers of the science. Some have finished their course, some are nearing their goal, and others continue to set the pace. Time and propriety permit only a brief reference to an incomplete roster of the teachers of chemistry who have propagated the science in the South. The following list is a summary of the responses to the questionnaire, grouped in years of service.

Fifty-Year Group:

J. W. Mallet, University of Virginia	59	years
F. P. Dunnington, University of Virginia	57	"
H. C. White, University of Georgia	55	"
M. P. Hardin, Virginia Military Institute	52	"
J. E. Willet, Mercer University	51	"
W. B. Burney, University of South Carolina	50	"
F. P. Venable, University of North Carolina	50	"



Southern Chemistry Teachers of Fifty Years' Service

Forty-Year Group:

R. W. Brackett, Clemson College	47	years
Robert Peter, Transylvania College	46	"
B. B. Ross, Alabama Polytechnic Institute	46	"
J. F. Bonnell, Emory University	45	"
J. F. McGill, Vanderbilt University	44	"
F. E. Tuttle, University of Kentucky	41	"
J. W. Caldwell, Tulane University	40	"
Hunter Pendelton, Virginia Military Institute	40	"
J. N. Swan, University of Mississippi	40	"

Thirty-Year Group:

Bennett Puryear, University of Richmond	38	years
C. E. Coates, Louisiana State University	37	"
W. F. Hand, Mississippi A. & M. College	37	"
F. W. Martin, Randolph-Macon College	37	"
J. W. Provine, Mississippi College	37	"
J. R. Bailey, University of Texas	36	"
W. H. Emerson, Georgia School of Technology	36	"
H. W. Harper, University of Texas	36	"
J. L. Howe, Washington and Lee University	35	"
C. E. Wait, University of Tennessee	35	"
W. L. Dudley, Vanderbilt University	34	"
J. L. Beeson, Georgia State College for Women	33	"
Alfred Fairhurst, Transylvania College	33	"
E. P. Schoch, University of Texas	33	"
Cora Q. Walker, Mississippi State College for Women	33	"
W. A. Withers, North Carolina State College	33	"
H. B. Arbuckle, Davidson College	32	"
C. O. Hill, University of Tennessee	32	"
Garland Ryland, University of Richmond	32	"
R. M. Bird, University of Virginia	30	"
G. S. Fraps, Texas A. & M. College	30	"
A. S. Wheeler, University of North Carolina	30	"

These are the known few of the craft whom we desire to honor. The unknown many are of equal desert and should receive equal recognition. In honor of them in the South, we quote from Henry Van Dyke:

Famous educators plan new systems of pedagogy, but it is the unknown teacher who delivers and guides the young. For him no trumpets blare, no chariots wait, no golden decorations are decreed. He keeps the watch along the borders of darkness and makes the attack on the trenches of ignorance and folly. Patient in his daily duty, he strives to conquer the evil powers which are the enemies of youth. He awakens sleeping spirits. He quickens the indolent, encourages the eager, and steadies the unstable. He communicates his own joy in learning and shares with his students the best treasures of his mind. He lights many candles which in later years will shine back to cheer him. This is his reward.

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A CLASSIFICATION OF COMPOUNDS OF HYDROGEN AND NITROGEN*

L. F. Audrieth, University of Illinois, Urbana, Illinois

Most elements form hydrogen compounds, but in only a few instances is the capability of forming more than one hydride definitely expressed. The existence of a series of hydrides of one and the same element has been ascribed to the power of self-linkage which these possess. This property is most highly accentuated in the case of carbon and accounts for the multiplicity of carbon compounds and the extensiveness of organic chemistry.

As might be expected, this characteristic is also expressed by several of the other elements of the fourth group—however, to a diminishing degree as the atomic weights of the elements increase. The silanes, germanes, and stannanes give evidence of this fact. Elements in the neighboring groups likewise exhibit self-linkage and attention is called to the large number of boranes which have been prepared. To the right of carbon we find that phosphorus and nitrogen, and to a lesser extent sulfur and oxygen, manifest self-linkage and form series of hydrides, or compounds which are derivatives of such hydrides. Among the latter may be mentioned the alkyl and aryl substitution products which are considerably more stable than the parent substances. In many cases the hydrogen compounds are unknown, but their substitution products are well defined and characterized.

In the number and variety of such derivatives the element nitrogen ranks next to carbon. Since many of the nitrogen compounds are ones in which substitution of alkyl and aryl groups for the hydrogen atoms has taken place, they have been and still are considered as organic compounds. Yet, when considered from the point of view of the parent substances, the *hydronitrogens*, a classification is possible which the chemistry of organic nitrogen compounds has heretofore lacked. Furthermore, it becomes possible to simplify the chemistry of these substances by a consideration of type reactions—these having been obscured largely because the attached carbon radicals have been regarded as of paramount importance.

The hydronitrogens are those compounds known either in the free state or in the form of their derivatives, which are related to nitrogen chemistry as the hydrocarbons are to organic chemistry. As in the case of the hydrocarbons, various groups or homologous series of hydronitrogens may be construed possessing given type formulas, which depend upon the degree of saturation or the presence of double and triple bonds.

The simplest of all nitrogen hydrides, the methane analog of nitrogen, is ammonia. It forms the first member of the saturated series of hydronitrogens whose type formula is N_nH_{n+2}. The two lower members of

* Presented before the Illinois Academy of Sciences in April, 1930.

this series are known in the free state, the others only in the form of their organic derivatives. The saturated series is given in Table I.

TABLE I

Saturated Hydronitrogens

Type formula N_nH_{n+2}

NH_3	Ammonia	H_3N
N_2H_4	Hydrazine (diamide)	$H_2N{\cdot}NH_2$
N_3H_5	Triazane (prozane)	$H_2N{\cdot}NH{\cdot}NH_2$
N_4H_6	Tetrazane (buzane, hydrotetrazone)	$H_2N{\cdot}NH{\cdot}NH{\cdot}NH_2$

Unlike the methane series the individual members of the saturated series of hydronitrogens differ very decidedly from one another. Liquid ammonia as a parent solvent has been investigated quite thoroughly by many workers, in particular by Kraus, Franklin, and Cady.* It has been shown to be an excellent ionizing solvent and reactions have been found to take place in it with a facility which is surprising. Indeed, the study of nitrogen compounds, particularly the hydronitrogens and their derivatives, should be carried out in this solvent in preference to all others. Its character as a basic solvent by virtue of its affinity for the proton has permitted the investigation and characterization of many substances as acids which do not behave as such in more acidic solvents. Its affinity, not only for the proton but also for metallic ions, has given rise to the formation of many association compounds, chief among which are the ammonium salts and metal ammines.

Hydrazine, first prepared in the anhydrous state by Lobry de Bruyn (*1*), resembles ammonia in that it also acts as a parent solvent (*2*) in the anhydrous state. Like ammonia it forms solvates and association compounds. It is less basic in nature than ammonia. Its character as a reducing agent is accentuated to a marked degree over ammonia. The oxidation of hydrazine under certain conditions leads to a variety of products among which hydrazoic acid, nitrogen, and ammonia, have been identified. The mechanism of this reaction has been the subject of considerable investigation by Browne (*3*) and his co-workers and has lately led to a classification of oxidizing agents based upon the character of the products obtained. Oxidation of various organic hydrazines gives rise to derivatives of the higher hydronitrogens which will be discussed subsequently (*4*).

The triazanes (*5*) are a group of compounds, few in number, ill-defined, and in need of further study. They may be prepared by the reduction of triazenes. They are very unstable and undergo rapid decomposition.

* For a summary of reactions in liquid ammonia the reader is advised to consult the excellent series of articles by Fernelius and Johnson which have been published in the J. CHEM. EDUC. See p. 1850 of August, 1930, issue for complete references.

The tetrazanes form a larger and more interesting group. They are readily obtainable by the oxidation of tri-substituted hydrazines (1)

$$2R_2N{\cdot}NHR + O = R_2N{\cdot}NR{\cdot}NR{\cdot}NR_2 + H_2O \qquad (1)$$

Certain of the tetrazanes, such as hexaphenyltetrazane (*6*), exhibit the phenomenon of dissociation to form free nitrogen radicals, such as triphenylhydrazyl (2).

$$[(C_6H_5)_2N{\cdot}NC_6H_5—]_2 = 2(C_6H_5)_2N{\cdot}N—C_6H_5 \qquad (2)$$

This behavior is simply an expression of the reluctance of nitrogen to form long chains. Thus, there is exhibited by many of the tetrazanes a tendency toward stabilization by dissociation.

Hydroxylation of the lower members of the saturated series leads to a number of rather interesting derivatives. Thus, successive hydroxylation of ammonia gives hydroxylamine, dihydroxylamine, and nitrous acid.

$$NH_3 \longrightarrow NH(OH)_2 \longrightarrow N(OH)_3$$
$$\downarrow \qquad\qquad \downarrow$$
$$NOH \qquad\quad HNO_2$$
$$\downarrow$$
$$H_2N_2O_2$$

Hydroxylamine resembles both ammonia and hydrazine in its reactions and properties. It also constitutes the parent substance of a solvent system and, because of its pronounced affinity for the proton, may be classed as a basic solvent (*7*). Dihydroxylamine is a hypothetical intermediate reduction product of nitric acid, which is so unstable that it has never been isolated. Its dehydration product, nitroxyl (*8*), polymerizes rapidly to form hyponitrous acid. That it does exist for a very short time is indicated by the fact that it combines, at the moment of formation, with aldehydes to form hydroxamic acids and with nitroso compounds to give nitrosohydroxylamines (3). Its formation in the oxidation of hydroxylamine (*9*) has been postulated to account for the variegated character of the reaction products (4).

$$NOH + RCHO = RC(OH)NOH$$
$$NOH + C_6H_5NO = C_6H_5N(NO)OH \qquad (3)$$

$$NH_2OH + O = NOH + H_2O \qquad (4)$$

TABLE II

Unsaturated Hydronitrogens

(a) Type Formula N_nH_n

N_2H_2	Diimide	HN:NH
N_3H_3	Triazene (diazoamine)	$HN{:}N{\cdot}NH_2$
N_4H_4	Tetrazene (tetrazone)	$H_2N{\cdot}N{:}N{\cdot}NH_2$
	Isotetrazene (diazohydrazine, buzylene)	$HN{:}N{\cdot}NH{\cdot}NH_2$
	Ammonium azide	NH_4N_3
N_5H_5	Hydrazine azide	$N_2H_5N_3$

(*b*) *Type Formula* N_nH_{n-2}

N_3H	Hydrogen azide, hydrazoic acid, azoimide, hydronitric acid, triazoic acid	HN:N ⋮ N or
N_4H_2 ?	Diiminohydrazine	HN:N·N:NH
N_5H_3	Bisdiazoamine	HN:N·NH·N:NH
N_6H_4 ?	Bisdiazohydrazine	HN:N·NH·NH·N:NH

(*c*) *Type Formula* N_nH_{n-4}

N_8H_4	Octazotriene (octazone)	HN:N·NH·N:N·NH·N:NH

The N_nH_n Series

The members of the N_nH_n series are all characterized by the presence of a double bond. The simplest member of this series is diimide, the parent substance of the large group of azo compounds. Many attempts have been made to prepare the ethylene analog of the hydronitrogens, but those reactions which were expected to lead to its isolation invariably gave equimolecular mixtures of hydrogen and nitrogen. Hydroxydiimide, HON:NH, a hypothetical intermediate in the decomposition of ammonium nitrite (*10*), may be regarded as the parent substance of the diazo compounds. Where the formation of alkyl derivatives of hydroxydiimide is involved stabilization is effected by the splitting off of water to give such compounds as diazomethane, which may possess either the cyclic or the chain structure (5).

$$CH_3N{:}NOH = CH_2{:}N \vdots N \text{ or } H_2C\begin{matrix}N\\ \|\\ N\end{matrix} \qquad (5)$$

It is interesting to note in this connection that the formation of aryl diazo compounds by the action of an amine upon nitrous acid is equivalent to an ammonolysis, more strictly an "aminolysis" of nitrous acid (6).

$$RN\overset{\overset{H_2}{\frown}}{H_2} + \overset{\overset{O}{\frown}}{O}NOH = RN{:}NOH + H_2O \qquad (6)$$

Triazene, the parent substance of the diazoamino compounds, has been obtained in aqueous solution by the reduction of ammonium azide (*11*) at low temperatures using a zinc-copper couple and ammonium chloride. It may be regarded as a deammonation product of ortho-ammono-nitrous acid (theoretically an isomer of tetrazene). Actually, the diazoamino compounds are obtained by the action of aryl amines in excess upon nitrous acid or diazo compounds. These reactions are therefore solvolytic in nature and involve the complete replacement in nitrous acid of the last vestiges of the water system (7).

$$RN\overset{\overset{H_2}{\frown}}{H_2} + \overset{\overset{O}{\frown}}{O}N\overset{\overset{OH}{\frown}}{OH} + \overset{\overset{H}{\frown}}{H}NR = RN{:}N{\cdot}NHR \qquad (7)$$

The monosubstituted triazenes (*12*), which are considerably less stable, have thus far been prepared only by the reduction of the corresponding azides (8).

$$RN_3 + 2H = RN{:}N \cdot NH_2 \qquad (8)$$

Hydroxytriazenes are obtainable by the action of hydroxylamine upon diazo compounds (9).

$$RN{:}N\overline{|OH + H|}NOH = RN{:}N{\cdot}N\begin{matrix}OH\\H\end{matrix} \qquad (9)$$
$$\quad\quad\quad

dation of azidodithiocarbonates results in the formation of an extremely unstable disulfide, azidocarbondisulfide, $(SCSN_3)_2$ (*18*) which is likewise halogenoid in its properties and closely related to the thiuram-disulfides (14).

$$2HSCSN_3 + I_2 = 2HI + (SCSN_3)_2 \qquad (14)$$

Most methods for preparing hydrazoic acid or its substitution products involve the action of nitrous acid or one of its derivatives upon hydrazine or substituted hydrazines. These facts have caused Browne (*19*) to look upon hydrazoic acid as a hydrazo-nitrous acid, obtainable by the solvolytic action of hydrazine upon nitrous acid (15). Franklin (*20*), however, has pointed out that hydrazoic acid is a strong delectronator

$$3N_2H_4 + HNO_2 = \left[N(N_2H_3)_3\right] \longrightarrow HN_3 \qquad (15)$$

and may be regarded as a deammonation product of ortho-ammono-nitric acid (16). That such a postulation is in accord with the facts is evidenced

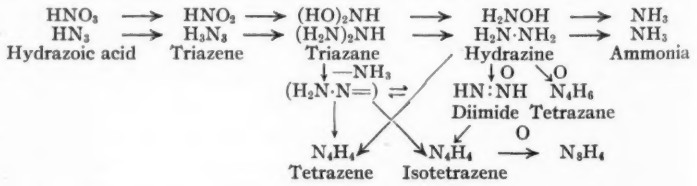
$$N(NH_2)_5 = HN_3 + 3NH_3 \qquad (16)$$

by the solubility of the noble metals in a mixture of hydrochloric and hydrazoic acids and by the nitridizing action of potassium azide in the conversion of potassium cyanide, an ammono-carbonite, to potassium cyanamide, an ammono-carbonate (17). Its preparation by the action

$$KN_3 + KNC = K_2NCN + N_2 \qquad (17)$$

of fused potassium amide upon potassium nitrate is further support in favor of this postulation.

The reduction of hydrazoic acid and its derivatives leads to a variety of products depending upon the character of the reducing agent and the nature of the substituent groups. From a consideration of hydrazoic acid as an ammono-nitric acid this mechanism becomes clear by analogy with the Bancroftian theory for the reduction of aquo-nitric acid.



The nitridation of hydrazine to give hydrazoic acid is quite analogous to the complete oxidation of hydroxylamine to nitric acid. This mechanism is, furthermore, interesting as it brings together the inter-relationship of the whole group of hydronitrogens and their consideration as ammono compounds from the Franklin point of view.

The multiplicity of the reactions of organic azides makes their study an extremely interesting one. Condensation with hydrogen cyanide, nitriles and cyanogen halides leads to the formation of tetrazole derivatives (18).

$$RCN + HN_3 = R{-}C\begin{array}{l}\diagup N{=}N \\ \quad \| \\ \diagdown N{-}N \\ \quad H\end{array} \qquad (18)$$

Reduction offers the only known method for preparing mono-substituted triazenes.

No derivatives of diiminohydrazine or of bisdiazohydrazine have as yet been prepared. The bisdiazoamino compounds are well known and easily obtainable by the interaction of diazo compounds in excess with ammonia and amines.

The octazotrienes (*21*) may be obtained by the gentle oxidation of 1,2-disubstituted isotetrazenes (19). The resulting compounds form the

$$2RN{:}N{\cdot}NR{\cdot}NH_2 \xrightarrow{O} RN{:}N{\cdot}NR{\cdot}N{:}N{\cdot}NR{\cdot}N{:}NR \qquad (19)$$

longest nitrogen chains. They are very unstable and decompose readily to give triazenes and nitrogen.

Summary

1. Homologous series of hydronitrogens exist. A consideration of organic nitrogen compounds as derivatives of these would do much to clarify our knowledge concerning them.

2. Nitrogen exhibits self-linkage to a remarkable degree, but not to the extent of carbon. The hydrocarbons are stable, whereas most of the hydronitrogens are so unstable that they cannot be obtained in the free state. Even their organic substitution products undergo ready decomposition. Experimental evidence thus far accumulated indicates that chains of more than eight nitrogen atoms are probably non-existent.

3. Individual members of the homologous series of hydronitrogens show no great similarity, but rather a decided diversity in properties. Here again do they differ from homologous series of hydrocarbons. They are, however, very much more reactive and undergo oxidation, reduction, and chemical change very readily.

4. It is suggested that the hydronitrogens be studied with particular reference to liquid ammonia as the parent solvent.

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UNITED STATES CIVIL-SERVICE EXAMINATION FOR JUNIOR METALLURGIST

The United States Civil-Service Commissioner announces an open competitive examination for JUNIOR METALLURGIST, at entrance salaries ranging from $2000 to $2500 a year. Applications must be on file with the Civil-Service Commission at Washington, D. C., not later than September 9, 1930. The examination is to fill vacancies occurring in the Federal classified service throughout the United States.

The duties will consist of general metallurgical work connected with the fabrication of manufactured articles, either ferrous or non-ferrous; general metallurgical work including process control, physical testing of metallurgical materials or ores, microphotography and research work on a large variety of metallurgical problems.

The optional subjects are (1) physical metallurgy and (2) recovery metallurgy.

Competitors will be rated on practical questions on general metallurgy, elementary physics, elementary chemistry and the optional subject chosen, and on a thesis to be handed to the examiner on the day of the examination.

Full information may be obtained from the United States Civil-Service Commission, Washington, D. C., or from the Secretary of the United States Civil-Service Board of Examiners at the post office or customhouse in any city.

Steam Used in Making Inflammable Gas. Steam and illuminating gas, fed into an electrically operated "cracking" device, are made into a gas that will take the place of hydrogen in many industries at a tenth the cost. The new apparatus was developed by F. P. Wilson, Jr., of the General Electric Company, and is now in actual use in their plant. The gas, called "electrolene," consists largely of hydrogen combined with carbon monoxide; but carbon dioxide, oxygen, and other gases present in the original illuminating gas are removed. Like hydrogen, it can be used in brazing and in various types of furnaces for high heats.—*Science Service*

DISTILLATION AS AN ALCHEMICAL ART*

GUSTAV EGLOFF AND C. D. LOWRY, JR., UNIVERSAL OIL PRODUCTS CO., CHICAGO, ILLINOIS

The process of distillation (*6*) is usually accepted as a commonplace of laboratory procedure, and an essential in the industries, with little thought of its history. Yet discovery of many of the principles of distillation far antedate the dawn of exact science, and the beginnings of the distillation art are lost in the mist of antiquity.

FIGURE 1.—STILL OF THE FOURTH CENTURY (Berthelot, 1888).

In the third century before Christ Aristotle knew that sweet water could be made by evaporating salt water and condensing the steam. In the first century A.D. Dioscorides hung flocks of wool in the vapors of boiling liquids, and by wringing out the wool secured distillates. Berthelot (*4*) pictures a still which he ascribes to the fourth century (Figure 1). He also shows a more highly developed apparatus, attributed to the eleventh century (Figure 2), in which the still head has three outlets. The alchemical books of the sixteenth and seventeenth centuries are replete with representations of distillation equipment, some of it quite complex and showing in its design great ingenuity.

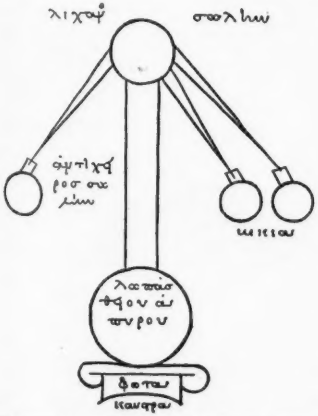

FIGURE 2.—ELEVENTH CENTURY STILL (Berthelot.)

Alchemical Stills

The simplest stills used by the alchemists were gourd-shaped vessels or "cucurbitae." To the gourds were attached still heads or "alembics" of several types. The alembics, "fistulata," were used in the original separation of volatile matter from non-volatile, while the "rostrata" were used in redistillation. A variety of these instruments are shown in Figures 3 and 4. These pictures were taken from the Latin work "Alchymia" by Andrew Libavius (*11*), published in Frankfurt in 1595.

The alchemists early found that it was wise to consider the properties of the substance to be distilled in choosing a distilling vessel. Jean Baptiste Porta in his "Natural Magick" (*14*)—"in which are set forth all the

* Presented before the Division of Chemical Education of the American Chemical Society at Atlanta, Georgia, April 7–11, 1930.

riches and delight of the natural sciences," explained quaintly the philosophy of his choice:

> Both the vessel and the receiver must be considered according to the nature of the things to be distilled. For if they be of a flatulent vaporous nature they will require large and low vessels and a more capacious receiver; or when the heat shall have raised up the flatulent matter and that find itself straightened in the narrow cavities it will seek some other vent and so tear the vessels to pieces (which will flie about with a great bounce and crack, not without endamaging the standers-by) and being at liberty will save itself from further harm. But if the things be hot and thin you must have vessels with a long and small neck. Things of a middle temper require vessels of a middle size. All which the industrious artificer may easily learn by the imitation of nature, who hath given angry and furious creatures as the lion and bear, thick bodies and short necks; to show that flatulent humors would pass out of vessels of a large bulk and the thicker part settle to the bottom; but then the stag, the estrich (ostrich), the camilpanther, gentler creatures and of thin spirits have slender bodies and long necks; to show that thin subtile spirits must be drawn through a much longer and narrower passage and be elevated higher to purify them.

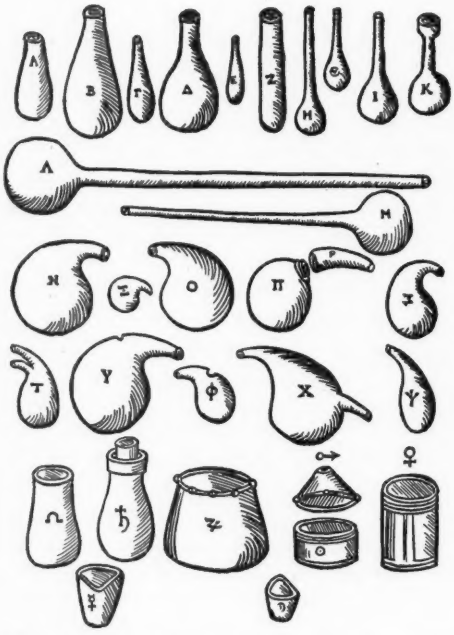

FIGURE 3.—ALCHEMICAL VESSELS FOR DISTILLATION
Those in the top row termed "cucurbitae."
(Libavius, 1606.)

Use of simple forms of apparatus in the distillation of nitric acid is portrayed in Figure 5. This plate is reproduced from "De Re Metallica" of Agricola, an important work on mining and metallurgy, published in 1556 (*1*).

Condensation of vapors was effected then, as now, by passing them through cold water. Even in early times, the tubes carrying the vapors were given a spiral form, "winding about with circling revolutions, or mutual crossings, or as it were with the circling of snakes" as in the familiar worm condenser.

The principle of steam distillation was known to the ancients. To

extract oils which were not easily volatile, vegetable material was boiled with a large volume of water, that in this way the oils might be "easily carried upward, accompanied by water."

Methods of Heating

Alchemical practice applied to stills several intensities of heat, depending on the nature of the material being treated. Four heatings were generally recognized: by direct fire, by a bath of "earth" (sand or ashes), by water-bath, or by "air" (air- or steam-bath). Paracelsus, who is renowned for his work on medical chemistry, but whose conduct has perpetuated his surname, Bombastus, as a synonym for loquacity, stated in the sixteenth century that only wood and similar objects should be distilled by direct fire. Roots and boughs of trees required milder heating, as by a bath of sand, while for leaves and fruits a still embedded in ashes should be used. The water-bath was advised in the distillation of herbs, flowers, and seeds (*12*).

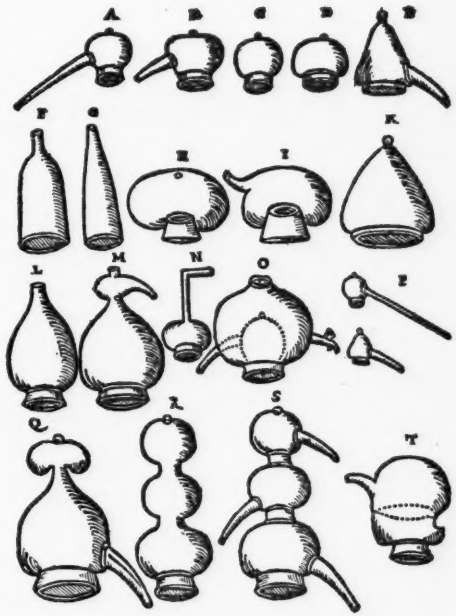

FIGURE 4.—STILL-HEADS USED BY THE ALCHEMISTS (ALEMBICS)

I. N. Alembics "fistulata"
A. B. Alembics "rostrata"
O. Alembic devised for water cooling
S. Fractionating still-head
(Libavius.)

Examples of sand-bath distillation are shown in Figure 6 (*3*). The bodies of the stills are below the surface of the sand, with only their necks and the alembics visible. The alchemists long ago discovered what countless chemists since have found out, that one must use care in distilling from a sand-bath. As far back as 1512 Hieronymus of Brunswick in "The Virtuous Book of Distillation" (*8*) observed that the fire must not be too hot, and that "one cannot, as with a water-bath, distil to dryness without harm."

The air-baths used by the ancients were not unlike those found in present-day laboratories. One is illustrated in Figure 7. Here again only the upper portions of the stills are visible.

The water-bath has long been used as a means of gentle heating during distillation. In France it is still termed "bain Marie," from one Marie

FIGURE 5.—ALCHEMICAL DISTILLATION APPARATUS IN USE

A—Furnace. B—Its round hole. C—Air-holes. D—Mouth of the furnace. E—Draught opening under it. F—Earthenware crucible. G—Ampulla. H—Operculum. I—Its spout. K—Other ampulla. L—Basket in which this is usually placed lest it should be broken.

(Agricola, 1556.)

who was a more or less mythical Egyptian alchemist. Figure 1 includes a water-bath used in the fourth century.

Such baths were made in past centuries, as at present, for heating many distilling vessels at the same time, as well as for single stills. Kircher (*9*) described a water-bath with which one could carry out sixty-six

distillations at one time. In Figure 8 the water-bath proper is separated by the wall at the left from the furnace, which is pictured separately at the right. The baths in olden times, as now, were usually filled with pure water, but some alchemists used sea water to raise the temperature.

FIGURE 6.—SAND-BATH DISTILLATION

A—Ampullae arranged in the vessels. B—An ampulla standing upright between iron rods. C—Ampullae placed in the sand which is contained in a box, the spouts of which reach from the opercula into ampullae placed under them. D—Ampullae likewise placed in sand which is contained in a box, of which the spout from the opercula extends crosswise into ampullae placed under them. E—Other ampullae receiving the distilled *aqua* and likewise arranged in sand contained in the lower boxes. F—Iron tripod, in which the ampulla is usually placed when there are not many particles of gold to be parted from the silver. G—Vessel.

(Agricola, Hoover Translation.)

The apparatus of Figure 9 was intended to prepare in one operation "most volatile spirits and quintessences." The still is placed in a water-bath, and has a long neck, in which is placed a dry sponge supported by a

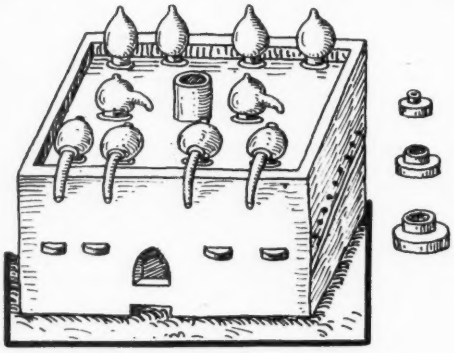

FIGURE 7.—HEATING WITH AN AIR-BATH
(Libavius.)

thread which allows it to be positioned wherever desired. The sponge probably caused considerable fractionation and prevented the rise of foam.

Sometimes, as in Figures 10 and 11 (*10*), the sun was used as a source of heat, its rays being focussed upon the still by a lens or a concave mirror. This method of heating, because of its mildness, was recommended for the preparation of medicine for the eyes. It was attended by some disadvantages, for although economical of fuel and labor, it could be used only in summer, and was inconvenient by reason of the constant change in the sun's position and the variation in the heating power of its rays.

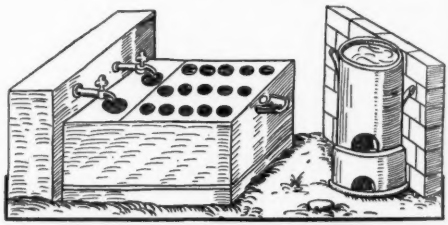

FIGURE 8.—MULTIPLE WATER-BATH
(Libavius.)

Sideward and Downward Distillation

With substances of low volatility the alchemists often found it impossible to make the vapors rise high enough in apparatus of the usual type to pass over into the condensing system. For such materials they devised distillation equipment in which the vapors left at the side or at the bottom of the still. Porta (*16*) wrote, "when a thing is unwilling to ascend, we teach it to rise by degrees by inclining the vessel, until it becomes thinner and knows how to ascend." A retort-like still and receiver for sideward distillation

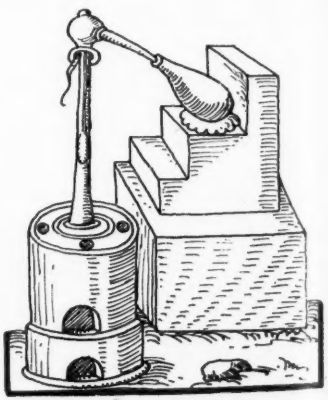

FIGURE 9.—WATER-BATH STILL FOR PRODUCING A VERY VOLATILE FRACTION
(Libavius.)

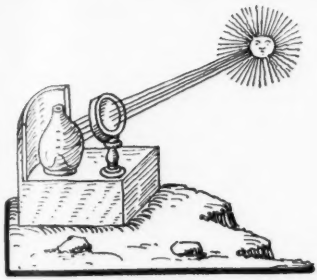

FIGURE 10.—SOLAR HEATING USING LENS
(Libavius.)

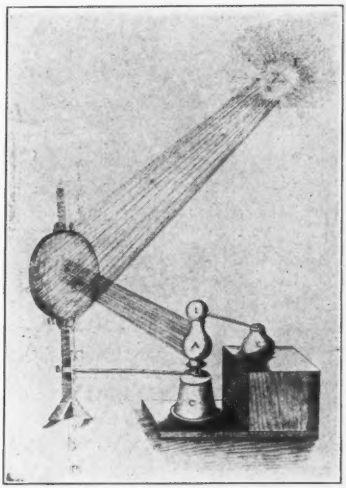

FIGURE 11.—SOLAR HEATING USING A MIRROR
(Kircher, Mundus Subterraneus, 1665.)

are shown in Figure 12, both alone and in a furnace setting. Sideward stills, in an air-bath, are also shown in Figure 13.

In downward distillation the still was above and the distilled material driven downward by heat from a fire or the sun, and condensed in a cooler vessel below. Arrangements such as that shown in Figure 14 were used. Porta (*15*) describes this apparatus and its employment as follows:

> Make an oval brass vessel, as I advised before, with a hole bored through the bottom: to which fasten a pipe that may arise up to the mouth of the vessel; let the mouth of it be wide, like a trumpet or tunnel, so that the long neck of a gourd-glass may pass through the pipe of it, and the wide mouth of the vessel under, may by degrees receive the swelling part of the neck. Adapt a cover to this vessel that it may be close stopt and luted as we said before. You must make a furnace on purpose for this use: for the fire must not be made in the bottom but about the vessel. The use is this: fill the glass with flowers or other things; put in some wire lute strings that they may not fall out again when the glass is inverted. Thrust the neck through the brass pipe: set the vessel on the furnace and fill with water round about the arising pipe. Put on the cover and plaster it about: set the receiver under the furnace that it may catch

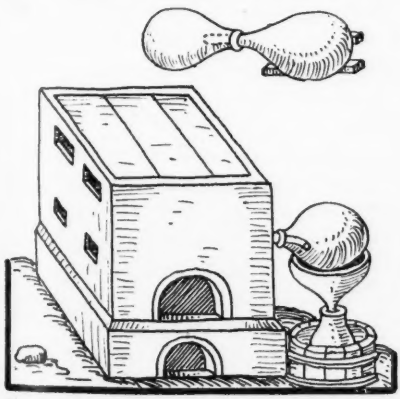

FIGURE 12.—STILL AND RECEIVER, WITH FURNACE, USED IN SIDEWARD DISTILLATION
(Libavius.)

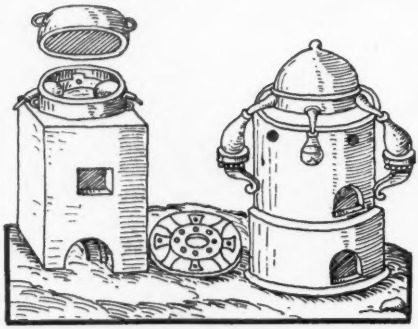

FIGURE 13.—APPARATUS FOR SIDEWARD DISTILLATION
(Libavius.)

the dropping water and oyl; then kindle the fire about the sides of the pot, the violence of which will elevate vapors of boiling water, which beating against the concave part of the cover will be reverberated upon the bottom of the gourd glass, whose fervent heat will turn water and oyl into vapor and drive it down into the receiver.

Porta advised this type of distillation for

Many tenuous oyly flowers as of rosemary, juniper, and other things as musk, amber of civet, gum and such like, out of which may be drawn oyls very sweet and medicinable; but they are of so thin a substance that there is a great hazard of burning them when they are forced by the heat of the fire, without which neither fat things will be elevated nor oyl extracted. Therefore to remedy these inconveniences I have invented an instrument to which oyl shall descend without any labor or danger of burning.

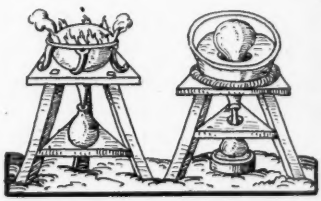

FIGURE 14.—DOWNWARD DISTILLATION
(Libavius.)

Another downward distillation set-up is shown in Figure 15. Here the first receiver is also a fractionating device, so arranged that the more volatile material passed from it through the water condenser and into the final receiver. In Figure 16 (*2*) is shown the production of mercury by downward distillation from its ore.

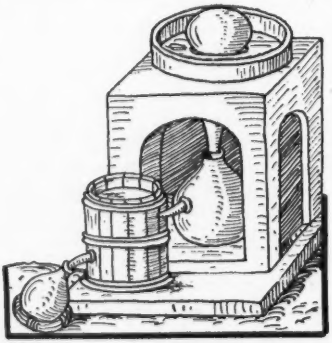

FIGURE 15.—DOWNWARD DISTILLATION WITH FRACTIONATION
(Libavius.)

Fractionation

An essential in many distillations is the separation of the distillate into portions of different volatility. Present-day fractionating apparatus secures this separation by refluxing the distilled vapors as they arise, so that the heavier portions are continuously returned to the still, by partially condensing the vapors in a tower and from the tower withdrawing several streams of distillate of different properties, and by fractionally condensing

A—Hearth. B—Poles. C—Hearth without fire in which the pots are placed. D—Rocks. E—Rows of pots. F—Upper pots. G—Lower pots.

FIGURE 16.—DOWNWARD DISTILLATION OF MERCURY FROM ITS ORE (Agricola, Hoover Translation.)

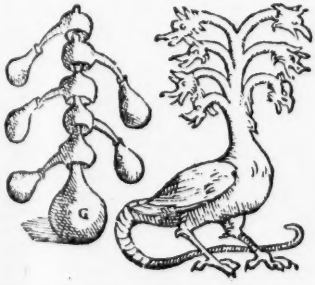

FIGURE 17.—THE ORIGIN OF MULTIPLE STILL HEADS (Porta, De Distillatione, 1608).

the vapors in a series of receivers. These practices are not new. The alchemists realized their importance and designed apparatus to make use of them hundreds of years ago.

To take from a single still two or more streams of distillate of different properties, towers were constructed to which several receivers could be attached. Some alchemists persuaded themselves that the development of these towers arose from knowledge of the anatomy of the hydra pictured with such a tower in Figure 17 (*17*).

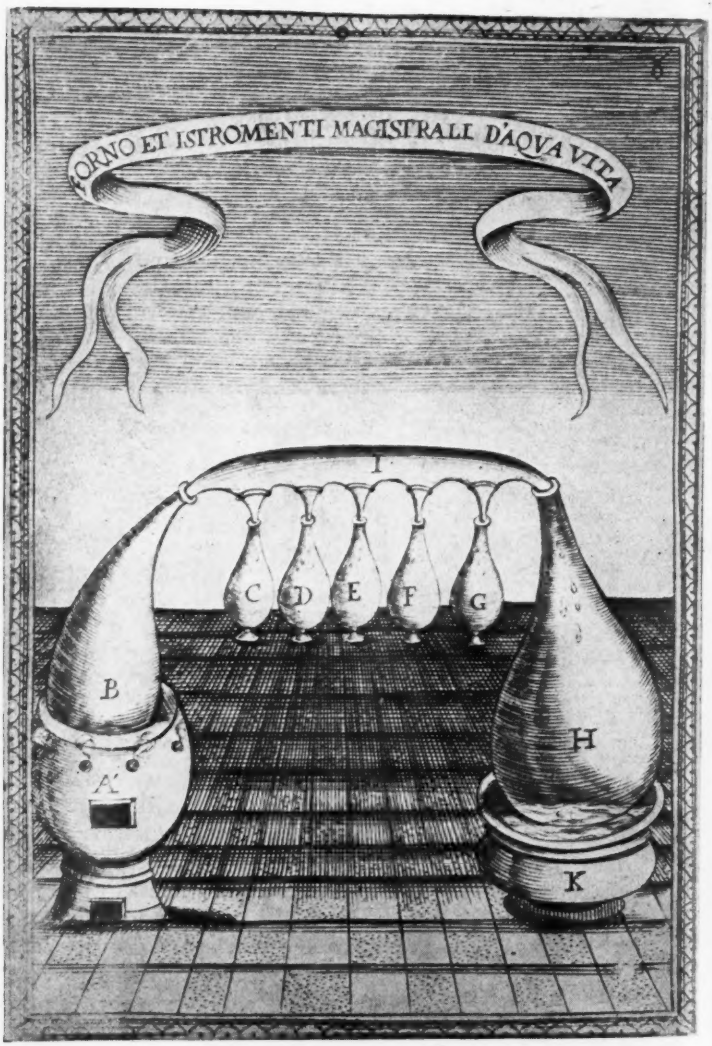

FIGURE 18.—FRACTIONATING APPARATUS
(Donato d'Eremita Naples 1624, Dell' Elixir Vitae.)

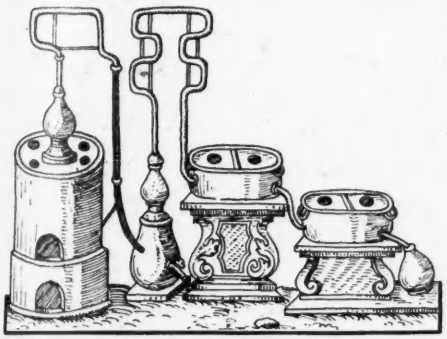

FIGURE 19.—STILL WITH AIR CONDENSATION AND PRELIMINARY RECEIVER FOR FRACTIONAL DISTILLATION
(Libavius.)

The distilling system shown in Figure 19 secures fractionation by providing considerable air-cooled surface to cause refluxing of the condensed vapors back into the still, and by effecting partial condensation in a first receiver (which, following technical practice, may be called a dephlegmator) before the vapors pass through the water condenser to the final receiver. The furnace and still are at the left, with the enlarged still-head and bent pipe above the still giving a large air-cooled surface. Following this is a receiver, which collects the higher boiling portions of the distillate, and is also provided with a bent delivery pipe to allow air condensation. This receiver has an outlet for withdrawal of condensed liquid without interrupting the distillation. From this vessel the uncondensed vapors pass through two water condensers and to the final receiver.

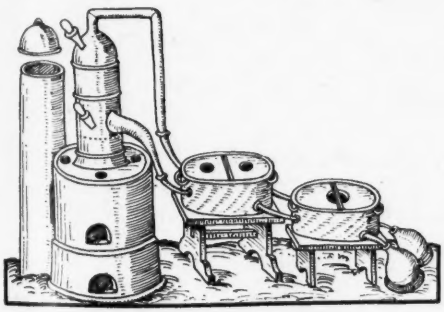

FIGURE 21.—DUPLEX STILL
(Libavius.)

A fractionating apparatus of a somewhat different type is shown in Figure 18 (*5*). It is adapted to taking off five small fractions and one larger fraction by fractional condensation. Such a still would be useful, for example, in distilling a mixture of alcohol and water.

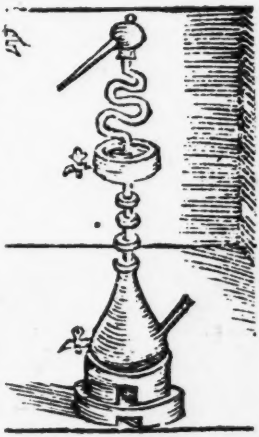

FIGURE 20.—STILL WITH AIR- AND WATER-COOLED COLUMN
(Philiatrus, 1555.)

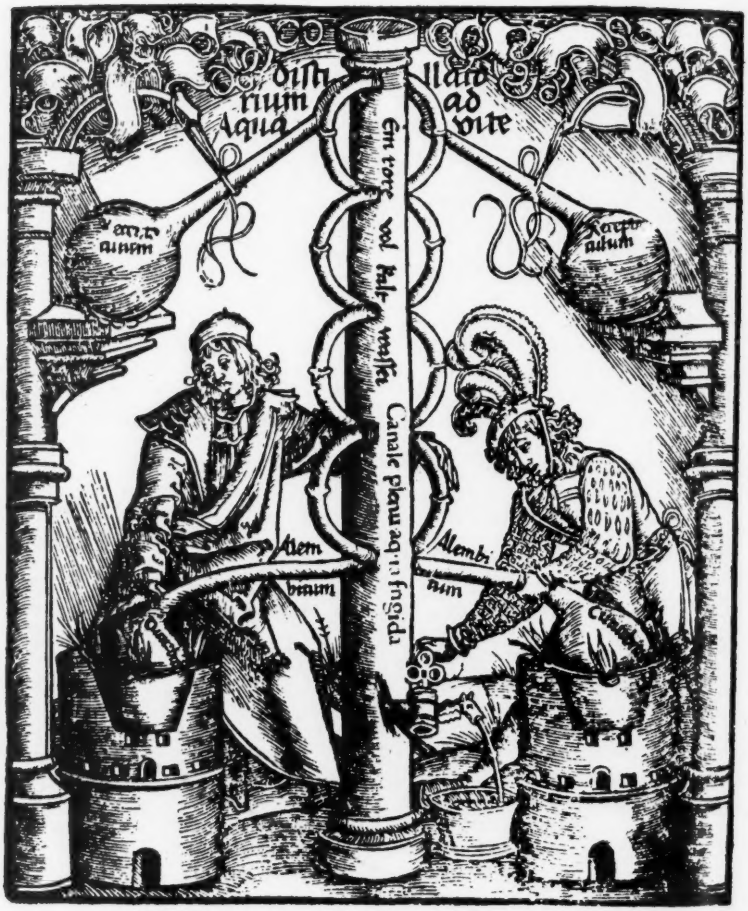

FIGURE 22.—STILL WITH COOLED REFLUXING COLUMN
(Hieronymus of Brunswick, The Virtuous Book of Distillation. 1512.)

Refluxing was also sometimes brought about by regulated cooling of the still head, as in Figure 20 (*13*), or by passing the vapors upward through tubes in counterflow relation to a cooling stream of water, as in Figure 22.

More Complex Stills

The apparatus of Figure 21, combines two stills into one. Inside the furnace is a globular still, above which a short column rises. This column bears a vapor outlet, and in it is also inserted a tube through which

material to be distilled may be added. Above this inlet and outlet and within the column is a second distilling vessel, marked by the two bands about the column, which is fed by the upper of the two inlets shown and is heated by the vapors from the lower still. The vapors from the second still leave by the outlet at the top of the column and pass through the condensers to a separate receiver. The lower still is intended for the treatment of aqueous liquids, and the upper for the redistillation of spirits. At the left of the apparatus is a tower to be filled with fuel for gradual addition to the fire. A cap is placed at the top of this tower to keep the fuel from burning while still within it, and at its base is a device to regulate the combustion.

FIGURE 23.—STILL WITH SEPARATE HEATING ELEMENT
(Glauber, 1651.)

In Figure 23 is represented an apparatus of Glauber (7), consisting of a copper bulb subjected to heat, connected with a barrel in which the distillation actually took place, and this in turn with a condenser. The advantages he found in such a device were that the barrel was easily replaced, so that there was no necessity of providing a large and expensive still,

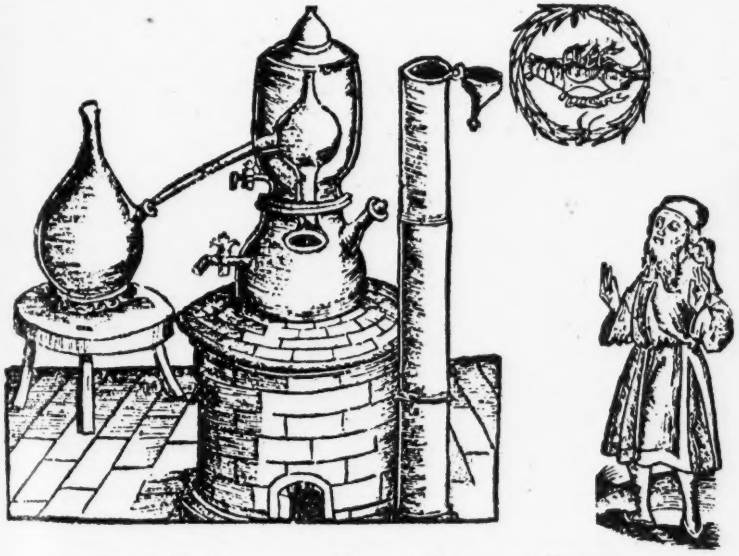

FIGURE 24.—CONTINUOUS STILL WITH CONTROLLED REFLUX
(Brunswick, 1512.)

and that a partition might be interposed between the furnace and the still itself, making both for secrecy and for safety, "for ofttimes the care of the fire is committed to heedless servants that break glass instruments by their carelessness."

The still in Figure 24 is fitted with inlet and outlet, allowing continuous operation, and also a fuel tower. The still head is cooled for controlled refluxing and condensation of the vapors.

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(15) *Ibid.*, p. 263.
(16) *Ibid.*
(17) PORTA, "De Distillatione," **1608.**

The Making of a Periodical. "Consider the making of a periodical: what is the difference between a fairly good one and a really great one? It is only the difference of personalities and ideas that go into them. This is so simple that it sounds silly to state it, but there is no secret about making a great magazine. You must have, of course, a good craftsman at the head of it, a man of editorial skill, of good judgment, of some courage and of character, but these are all common qualities and with all these you will make but a fairly good magazine. The stuff to make a great periodical of is yet lacking and this stuff is a prodigality of ideas—such as no one man has or can have. Ideas must grow about it with the very luxuriance of nature, must come to it from every quarter. It must have enough waste material to make all the other periodicals better than they are now. This requires more than the acquaintance and good will and casual suggestions of fertile men; *it requires, to a degree, the identification of their personalities with it.*"—*"The Earlier Life and Letters of Walter H. Page."*

MODERN PHYSICS—A SURVEY.* PART II**

SAUL DUSHMAN,† GENERAL ELECTRIC COMPANY, SCHENECTADY, NEW YORK

New Quantum Mechanics

The solution of the difficulties which thus presented themselves to physicists until within the past four years has been approached from two directions which were believed at first to be quite different, but which have been shown on closer investigation to be merely different methods of expressing the same idea. As a preliminary to the discussion of these solutions we shall quote the following remarks from Born's lectures:

In seeking a line of attack for the remodeling of the theory, it must be borne in mind that weak palliatives cannot overcome the staggering difficulties so far encountered but that the change must reach its very foundations. It is necessary to search for a general principle, a philosophical idea, which has proved successful in other similar cases. We look back to the time before the advent of the theory of relativity, when the electrodynamics of moving bodies was in difficulties similar to those of the atomic theory of today. Then Einstein found a way out of the difficulty by noting that the existing theory operated with a conception which did not correspond to any observable phenomenon in the physical world, the conception of simultaneity. He showed that it is fundamentally impossible to establish the simultaneity of two events occurring in different localities, but rather that a new definition, prescribing a definite method of measurement, is required. Einstein gave a method of measurement adapting itself to the structure of the laws of propagation of light and of electromagnetic phenomena in general. Its success justified the method and with it the initial principle involved: the *true laws of nature are relations between magnitudes which must be fundamentally observable.* If magnitudes lacking this property occur in our theories, it is a symptom of something defective. The development of the theory of relativity has shown the fertility of this idea, for the attempt to state the laws of nature in invariant form, independently of the system of coördinates, is nothing but the expression of the desire of avoiding magnitudes which are not observable. A similar situation exists in other branches of physics.

In the case of atomic theory, we have certainly introduced, as fundamental constituents, magnitudes of very doubtful observability, as, for instance, the position, velocity and period of the electron. What we really want to calculate by means of our theory and can be observed experimentally, are the energy levels and the emitted light frequencies derivable from them. The mean radius of the atom (atomic volume) is also an observable quantity which can be determined by the methods of the kinetic theory of gases or other analogous methods. On the other hand, no one has been able to give a method for the determination of the period of an electron in its orbit or even the position of the electron at a given instant. There seems to be no hope that this will ever become possible, for in order to determine lengths or times, measuring rods and clocks are required. The latter, however, consist themselves of atoms and therefore break down in the realm of atomic dimensions. It is necessary to see clearly the following points: all measurements of magnitudes of atomic order depend on

* An address given before the Physical Science Section of the Tenth Ohio State Educational Conference, held in Columbus, April 3–5, 1930; and printed in the *Proceedings*, and also in *Gen. Elec. Rev.*, **33**, 328–35 (June, 1930); *Ibid.*, **33**, 394–400 (July, 1930).

** Part I of this series of articles appeared in J. CHEM. EDUC., **7**, 1778–87 (Aug., 1930).

† Assistant Director, Research Laboratory, General Electric Company.

indirect conclusions; but the latter carry weight only when their train of thought is consistent with itself and corresponds to a certain region of our experience. But this is precisely not the case for atomic structures such as we have considered so far.

At this stage it appears justified to give up altogether the description of atoms by means of such quantities as "coördinates of the electrons" at a given time, and instead utilize such magnitudes as are really observable. To the latter belong, besides the energy levels which are directly measurable by electron impacts and the frequencies which are derivable from them and which are also directly measurable, the intensity and the polarization of the emitted waves. We therefore take from now on the point of view that the elementary waves are the primary data for the description of atomic processes and all other quantities are to be derived from them.

The work which led directly to the formulation of the new quantum mechanics was that of Kramers and Heisenberg on dispersion of light. They found it possible to obtain relations in which the effects of incident radiation on an atom could be expressed in terms of frequencies and amplitudes of the spectral lines emitted by the atom. This then led Heisenberg to attempt the development of a new scheme of quantum mechanics in which, instead of using such conceptions as orbits, orbital frequencies and magnitudes (which, by the very nature of things, can never be observed directly), actually observable energy levels and intensities of spectral lines could be correlated directly. For this purpose it was found necessary to apply a new kind of mathematics, the *matrix calculus*, which, although well known to mathematicians, was quite foreign to theoretical physicists. In the development of this matrix mechanics, Born, Jordan, and Pauli, along with Heisenberg, have played a prominent rôle.

The kind of mathematics used involves the use of complex quantities, or what Dirac has designated as "q-numbers," instead of ordinary or "c-numbers." The ordinary variables p and q of classical mechanics, which correspond, respectively, to actual momentum and coördinate of position for a material particle, are replaced in the new calculus by quantities which can have no physical interpretation, and the following remarks are, therefore, to be regarded only as an attempt to give a crude picture of the mathematical reasoning.

According to classical mechanics, any frequency $\nu_{m,n}$ due to a transition from state m to state n can arise only from a harmonic oscillator executing oscillations of this frequency. Heisenberg, therefore, introduces the notion of a *virtual oscillator*, which by its motion would emit a frequency and amplitude corresponding to any given frequency and intensity observed in the spectrum of the atom. Since there are an infinite number of possible transitions between the different energy levels, it is necessary to consider an infinite array of such virtual oscillators. The frequencies of these oscillators are, however, all interconnected by the Ritz relation or Bohr frequency condition, which may be expressed in the form:

$$\nu_{m,n} = \frac{W_m - W_n}{h}$$
$$= \frac{W_m - W_k}{h} + \frac{W_k - W_n}{h}$$
$$= \nu_{m,k} + \nu_{k,n}$$

where W_m, W_n, W_k are any three energy levels and $\nu_{m,n}$ $\nu_{m,k}$ $\nu_{k,n}$ denote frequencies of light emitted in transitions between these levels.

How can one deal mathematically with such an "orchestra" of oscillators? This is the question which Heisenberg asked himself. After he had derived rules of computation, it was recognized by Born that the method used by Heisenberg is essentially that previously devised by Cayley and other mathematicians for the solution of linear algebraic equations, and known as the calculus of matrices.

One of the most important features connected with this kind of algebra is the fact that the product $a \times b$ is no longer equal to $b \times a$. That is, multiplication is said to be *non-commutative*. In ordinary mathematics we meet with a similar condition of affairs when we consider the product of a number by an operator such as d/dx. For instance, $a \times (d/dx)b$ is usually different from $(d/dx)(ab)$ where a and b are functions of x. In consequence of this non-commutativity, the quantum condition assumes the incomprehensible form,

$$qp - pq = \frac{h}{2\pi}\sqrt{-1}$$

where it must be remembered that p and q are no longer ordinary or c-numbers, but designate elements in the p- and q-matrices. Instead of single variables, p and q, such as are used in ordinary mechanics, we now have infinite arrays of p- and q-terms, each array constituting a matrix, in which we have rows and columns as in determinants. Thus whereas in classical theory the motion of a linear oscillator would be represented by a Fourier series for a single coördinate q, and the frequencies of radiation emitted would be exclusively different possible harmonics of one fundamental frequency—the corresponding calculation in matrix mechanics replaces the single coördinate by a two-dimensional array of q's, each of these corresponding to a possible transition between two energy levels.

Now the rules of multiplication of matrices are such that they lead automatically to the Bohr frequency condition stated previously. Furthermore, by introducing the quantum condition given above for the p's and q's considered as matrix elements, and combining this condition with the proper Hamiltonian form of expression for the total energy as a function of the p's and q's, it is possible to obtain the correct expression for the different possible energy levels.

Thus the matrix mechanics is essentially a set of rules which enable us to calculate the correct energy levels and corresponding transition frequencies for any given atomic system. Heisenberg has shown that the method may be extended to systems such as those of helium and more complex atoms and gives, in each case, results in quantitative agreement with observation.

De Broglie's Phase Waves

Shortly after the publication of the first papers by Heisenberg and Born, Schrödinger also attacked the problem of atomic mechanics from another point of view which was inspired largely by certain speculations of de Broglie[2] on the association of wave motions with material particles.

To understand the considerations which influenced de Broglie toward postulating this suggestion, it is necessary to refer briefly to a relation, pointed out more than a century ago by Hamilton, between optics and dynamics. As mentioned already, the laws of dynamics may be expressed in their most general form by the principle of least action, according to which the path of a particle, or system of particles, from one given initial configuration to any other final configuration, the energy of the system remaining constant, is such that the *line integral of the momenta of all the particles is a minimum*. For a single particle this is stated mathematically in the form that

$$\int_o^s mv \cdot ds = \text{minimum}$$

where v is the velocity of the particle at any point and s denotes the distance measured along the path.

In optics there exists an analogous relation governing the path of a ray of light through a medium for which the refractive index (and, therefore, the velocity of light) varies from point to point. This is known as Fermat's principle, and states that the path of the ray is such that the *time* taken for the light to pass from one given point to another must be a *minimum*, that is

$$\int_o^s \frac{ds}{u} = \text{minimum}$$

where u denotes the velocity of light at any point and s, the distance along the path of the ray.

Now the laws of geometrical optics are more and more valid, the shorter the wave-length of light. For light waves comparable in length with those of the object upon which they impinge, we find that these laws are no longer applicable, and in order to understand the diffraction phenomena observed under these conditions it is necessary to consider light as a wave-

[2] *Loc. cit.* (Part I)—DE BROGLIE, *Annales de Physique*, **3**, 22–128 (1925).

motion. That is, Fermat's principle can no longer be applied. The analogy between this principle and that of least action suggested to de Broglie that perhaps the accepted mechanics of Newton (and the principle of least action itself) is also an approximation which is valid for macroscopic systems only because the wave-length is extremely small, but that for atomic systems this is no longer true, and therefore ordinary mechanics fails when applied to such cases.

In order to complete the parallelism between the principle of Fermat and that of Hamilton it is therefore necessary to assume that *along with the corpuscular motion of velocity v*, there *is associated a wave-motion of velocity u which is inversely proportional to v, i. e.*,

$$u \sim \frac{1}{mv}$$

Such a relation is actually found to exist between the phase velocity, u, of the individual waves and the group velocity, v, of a group of waves formed by the superposition of a large number of waves of slightly different wave-lengths. The classical illustration of such a wave-group is that formed in deep water by a series of individual waves of different wave-lengths. At certain points these waves add their amplitudes to produce a crest and at other points the individual waves interfere to form a hollow, and it is found that in general the velocity of the crest (group-velocity) is different from that of the separate wavelets (phase velocity).

De Broglie was led by these considerations to the conception that, associated with a particle of mass m_0 (the mass at zero velocity or "rest mass") and velocity v, there is a wave-motion for which the wave-length is given by

$$\lambda = \frac{h\sqrt{1 - v^2/c^2}}{m_0 v} = \frac{h}{m_0 v}$$

for small values of v, where c = velocity of light.

According to the theory of relativity, the total energy, E, of any particle of mass m_0 is given by

$$E = \frac{m_0 c^2}{\sqrt{1 - v^2/c^2}} = mc^2$$

where m is the mass for velocity v. Now, according to the quantum theory, the frequency associated with a quantity of energy, E, is given by E/h. Hence, the phase velocity or velocity of the individual waves constituting the group is given by

$$u = \nu\lambda = \frac{mc^2}{mv} = \frac{c^2}{v}.$$

The analogy between Fermat's principle and that of Hamilton is thus made formally complete. Before discussing the interpretation of this analogy, let us consider what values we can expect on the basis of de Brog-

lie's theory, for certain typical cases of corpuscular motion. The value of h as determined by different methods is 6.55×10^{-27} erg. sec. Hence for a mass of 1 g. moving with a velocity of 1 cm. per sec., the associated wave-length is 6.55×10^{-27} cm. This is certainly a value much too small to be measured by any sort of grating available. From the study of X-rays we know that it is possible by means of crystal lattices to measure wave-lengths ranging from 10^{-10} to 10^{-7} cm., while optically ruled gratings enable us to measure wave-lengths exceeding 10^{-6} cm. Thus if de Broglie's assumption is valid, we would expect to find that corpuscular motion will exhibit phenomena of the same nature as those previously associated with light waves, under those conditions where the momenta of the particles are of the order of magnitude $mv = h/10^{-10}$ to $mv = h/10^{-7}$, *i. e.*, for values of mv ranging from 6.55×10^{-17} to 6.55×10^{-20}. The magnitude of these values shows that we can expect such phenomena only in the case of atoms or electrons. Thus, according to the kinetic theory of gases, a hydrogen molecule ($m = 3.7 \times 10^{-24}$) has a velocity of about 2×10^{5} cm. sec.$^{-1}$ at room temperature. The value of mv is, therefore, 6.6×10^{-19} which is within the range mentioned above. An electron falling through a potential of 100 volts acquires a velocity of 5.9×10^{8} cm. sec.$^{-1}$. Multiplying this by the mass ($m = 9 \times 10^{-28}$), we obtain the result $mv = 5.3 \times 10^{-19}$, and $\lambda = 1.24 \times 10^{-8}$ cm. For cathode rays of 25,000-volt velocity, λ calculated in the same manner is 0.75×10^{-9} cm. approximately.

Thus we might expect to find in the case of atoms and electrons certain phenomena exhibiting the characteristics ordinarily associated with waves, and incidentally this would be an argument for de Broglie's postulate that for such particles it is no longer justifiable to expect exact results by application of Newtonian mechanics.

Diffraction of Electrons

Now as has happened in the history of science many times, the observations confirming this view became available very shortly after the publication of the work of de Broglie and Schrödinger.

This experimental evidence of the wave nature of matter was obtained by two physicists, C. J. Davisson and L. H. Germer,[6] in the Bell Telephone Laboratories. They observed that electrons of moderate velocities (20 to 200 volts) impinging on a single crystal of nickel are reflected more frequently in certain favored directions, depending upon the velocity of the electrons and upon the distance between the atomic layers, in the crystal lattice, which happen to be normal to the plane containing both the incident and reflected electron beams. Applying the same relations

[6] See GERMER, "Optical Experiments with Electrons. Parts I and II," J. CHEM. EDUC., **5**, 1041–55, 1255–71 (Sept. and Oct., 1928).

as had been used by Bragg to determine the wave-lengths of X-rays diffracted by a crystal lattice, Davisson and Germer found for the diffracted electrons values of λ in accordance with de Broglie's relation.

Furthermore, in England, G. P. Thomson actually sent high velocity electrons (15,000 to 30,000 volts) through thin metal foils and obtained on a photographic film diffraction patterns of exactly the same appearance as those obtained by Laue in his classical demonstration of the wave-nature of X-rays. G. P. Thomson merely applied the formula which had been used for X-rays to the diffraction of electron beams by the metal foil and obtained values of λ which were, again, in exact agreement with de Broglie's relation.

It is indeed a dramatic feature of recent developments in physics that the very same methods which had been used to demonstrate, without a shadow of a doubt, the undulatory nature of X-rays (which, in the Compton effect, inverse photo-electric effect and ionization effect exhibit corpuscular phenomena)—that these same methods should have been used for the same purpose in connection with rays (electron beams) which had hitherto been considered as *prima facie* corpuscular. For what could be more justly regarded as a corpuscle than the infinitesimal electron whose charge and mass had been determined by J. J. Thomson by recognized electrodynamical laws?

More recently evidence has been obtained that beams of atoms of hydrogen and other gases reflected from crystal surfaces also exhibit phenomena which may be interpreted from the undulatory point of view. But these observations are not yet as conclusive as those obtained in the case of electrons diffracted by crystals.

Principle of Indeterminism

How are we to understand this undulatory motion which is associated with a moving corpuscle? Such a corpuscle is defined, firstly, by its momentum (which we shall henceforth designate by the letter p), and secondly, by the instantaneous position, which may be designated by one or more coördinates of position q. Also, corresponding to the values of the p and q, the corpuscle possesses a certain total energy which is in general partly kinetic and partly potential. The energy is transmitted with the same velocity as the corpuscle, consequently it must be regarded as located at any instant at the same point in space as the corpuscle.

Now in a monochromatic plane wave, extending to infinity in both directions, it is not possible to choose any given point as that at which the energy is located at a given instant, for all points in the infinitely long train have equal claim to be chosen. But in a group of waves formed by the superposition of a large number of different frequencies, the energy is transmitted at the same velocity as that of the crest or that portion of

the resultant wave formed by the addition of the amplitudes of the individual waves. That is, *the energy is transmitted with the same velocity as that of the group*. Hence we must represent the corpuscle in motion as located within the region occupied by this crest and the latter as traveling with the same velocity v as that of the corpuscle.

The fact that the velocity of the individual waves, or phase-velocity, is given by c^2/v, which is greater than the velocity of light, need not worry us, since no energy is actually transmitted with this velocity. This conclusion is, therefore, not in contradiction with the theory of relativity.

It is evident that in the superposition of waves of different wave-lengths the region over which these waves may be caused to add their amplitudes and thus form a crest, of distinctly greater amplitude, is *narrower, the greater the range of wave-lengths*. Consequently, if we wish to define the *position* of the particle at any instant with a high degree of exactness, it is necessary to choose as large a range of wave-lengths as possible. The width of the crest will in fact be a measure of the uncertainty in locating the instantaneous position. On the other hand, the momentum of the particle and therefore its velocity is determined by the wave-length of the associated wave-motion, and since it has been found necessary to assume a large range of wave-lengths in order to define the position more accurately, it follows that the velocity cannot be defined with the same degree of exactness. Thus, on the basis of the wave conception of corpuscular motion, there exists a fundamental limitation upon the degree of certainty with which both position and velocity can be determined simultaneously.

These considerations led Heisenberg to formulate a generalization which defines the exact nature of the limitation. For ordinary cases of macroscopic particles, the degree of uncertainty is so small that it is much beyond the limits of measurement, but for microscopic systems, such as atoms and electrons, the existence of the limitation becomes of fundamental importance. As stated by J. H. Van Vleck,[7] Heisenberg's Principle of Uncertainty or Indeterminism postulates that,

> When dealing with amounts of action (momentum $\times$ distance) comparable with Planck's constant, h, one cannot assign accurate numerical values simultaneously to a coördinate and its corresponding momentum.

The interesting point is that the quantum constant, h, which determines the magnitude of the ultimate units of energy also appears here in an apparently new rôle. However, a consideration of the dimensions of h leads to a further interpretation of the Uncertainty Principle. From the relation $h = E/\nu$, it is seen that h has the dimensions of energy $\times$ time, *i. e.*, $mv^2 \times t$. Since this is identical with $mv \times vt = p \times q$, where p denotes a momentum and q a distance along the coördinate, it is readily shown

[7] VAN VLECK, "New Quantum Mechanics," *Chem. Rev.*, **5**, 467 (1928).

that the Uncertainty Principle can also be stated more precisely in the following form:

If Δp denote the inaccuracy in specifying a momentum, and Δq that in specifying the corresponding coördinate, then the product $\Delta p . \Delta q$ of the two errors is always of the same order of magnitude as constant h, that is

$$\Delta p \cdot \Delta q \sim h.$$

The significance of this relation for atomic phenomena is best presented in the following quotation which is, again, taken from Van Vleck's paper:

This (he states, in reference to the above relation) is the so-called *Heisenberg Indeterminism Principle*, and, like the second law of thermodynamics, is very useful in predicting what experiments are possible, and what are inherently impossible. Thus high precision in position implies low precision in velocity, and *vice versa*, for the error Δv is of the order $h/(m\Delta x)$, and therefore increases as we decrease Δx. We may illustrate this in a crude arithmetical way by considering the motion of an electron. If we specify that this electron is exactly at a given position, say the origin, at a given instant $t = 0$, then the error Δx is zero, and consequently the error Δv is infinite; this means that the velocity is inherently undetermined and so can range anywhere from $-\infty$ to $+\infty$; so that at any subsequent instant of time, say one second, there is an overwhelming chance that the electron be an infinite distance away. Suppose, however, that instead of aiming to specify accurately the position of the electron at $t = 0$, we merely say that then it is somewhere between $x = -1/2$ and $x = +1/2$; then $\Delta x = 1$, and Δv is of the order h/m; now $h = 6.55 \times 10^{-27}$, while for an electron $m = 0.9 \times 10^{-27}$, hence the error Δv in velocity is 6.55/0.9, or about 7 centimeters a second. One could then not give accurately a numerical velocity, say 300 cm. per sec., but one could say that the velocity lay somewhere between about $296\frac{1}{2}$ and $303\frac{1}{2}$ cm. per sec., so that after one second the electron would be between about $x = 296$ and $x = 304$. (This is only a very crude calculation; a more accurate study leads to a Gaussian error curve.)

Another and better illustration of the Heisenberg Indeterminism Principle is furnished by an attempt to measure simultaneously both the position and frequency of a packet or wave-train of light energy. A prism will record a train of waves as being strictly monochromatic only if the train is infinitely long; the termination of the optical disturbance after a finite time interval will cause an interruption in periodicity and make the light in the prism appear diffuse. If the train contains n waves, it can be shown that the diffuseness in its spectrum will be of the order $1/n$, or in other words the fractional error $\Delta\nu/\nu$ in determining the frequency is comparable with $1/n$. If, following the light quant theory, we assign a packet or "quant" of light a momentum $p = h\nu/c$, then Δp is of the order $h\nu/cn$. On the other hand, the length of the wave-train is $n\lambda$, where λ is the wave-length, and consequently the position of the light is indefinite to an extent $\Delta x = n\lambda$. As $\nu = c/\lambda$, the product $\Delta x \Delta p$ of the two errors is of the order of Planck's h.

Because of the ambiguity resulting from the Heisenberg Indeterminism Principle, the future of a dynamical system can never be predicted with certainty. Instead only the *probability* that an electron be in a given configuration can be determined, and the future is only statistically determined. This is in sharp contrast to the "causality principle" of classical dynamics, whereby the subsequent history of a dynamical system is determined if we know its initial coördinates and velocities. The uncertainty as to subsequent motion in quantum mechanics is, however, perhaps not due so much to failure of the ordinary cause and effect relation as to the inevitably indeterminate

character of the initial conditions, as by the Heisenberg Indeterminism Principle one cannot give both the initial position and velocity accurately. This contrast between classical determinism and quantum indeterminism should interest the philosopher as well as the chemist or physicist, and is indicated graphically in the table.

TABLE I

Classical determinism	*Quantum indeterminism*
Given initially x, y, z, V_x, V_y, V_z	Given V_x, V_y, V_z accurately; then x, y, z, are undetermined (*i. e.*, all values of x, y, z, are equally probable), or vice versa x, y, z, given and V_x, V_y, V_z, undetermined
↓ (Arrow indicates calculation by classical dynamics)	↓ (Arrow indicates calculation by quantum dynamics)
Accurate determination of x, y, z, V_x, V_y, V_z at all subsequent times	Only statistical determination of x, y, z, V_x, V_y, V_z at subsequent times

Thus quantum mechanics is essentially a means of calculating the probabilities of events. In a laboratory experiment one performs certain operations and observes certain consequences. The goal of a theory must ever be to explain "what goes out" in terms of "what is put in." At first thought it may appear as if the purely statistical correlation between cause and effect demanded by quantum mechanics is contradictory to the precision with which experiments can be performed. Experiments with large-scale quantities, however, involve so many quanta that the Heisenberg indeterminism is obscured, and so there is only apparently a "sharp" correlation. On the other hand, our ordinary atomic or molecular experiments are in most cases fundamentally statistical in character, as what is measured is not particular values of the dynamical variables, but rather *average values* of certain functions of these variables, or else *distributions* telling how they are scattered over a wide range of values. Such statistical quantities have a meaning in, and can be calculated with, quantum mechanics, and so there is no contradiction of Heisenberg's principle.

To be specific, let us consider the classical concept of an electronic orbit. We have extrapolated this idea from an experience with Newtonian mechanics in calculating planetary motions. In the latter problem we obtain splendid agreement between observations and calculations because the positions of the planets in our gross scale of time and space are unaffected by the act of observing. But is it possible to observe an orbit of an electron? The answer must be in the negative, because whatever experiment we devise to make such an observation will spoil the system. For it would be necessary to illuminate the particle, and to obtain a more precise determination of the instantaneous position we would use gamma rays. But in consequence of the Compton effect the electron would suffer a recoil in a direction which is determined by the change in frequency of the recoiling photon. *Thus by the very act of observation all possibility has been removed of determining accurately the position of the electron at the instant of observation.*

As Bohr has remarked in a notable address on the same subject:[4]

> Our usual description of physical phenomena is based entirely on the idea that the phenomena concerned may be observed, without disturbing them appreciably.... Now the quantum postulate implies that any observation of atomic phenomena will involve an interaction with the agency of observation not to be neglected.... Just as the relativity theory has taught us that the convenience of distinguishing sharply between space and time rests solely on the smallness of the velocities ordinarily met with compared to the velocity of light, we learn from the quantum theory that the appropriateness of our usual casual space-time description depends entirely upon the small value of the quantum of action as compared to the actions involved in ordinary sense perceptions.

The Principle of Indeterminism stated for a coördinate and momentum in a previous equation may also be applied to the simultaneous determination of energy and time in the form

$$\Delta t \cdot \Delta E = \Delta x \cdot \Delta p \sim h.$$

Thus, given an absolutely monochromatic wave (for which, therefore, $\Delta E = 0$), then as pointed out in the quotation from Van Vleck, the wave-train must be infinitely long, and therefore the uncertainty in t is infinitely great. The representation in wave mechanics of a particle, moving with momentum mv, by a wave packet necessarily leads to an uncertainty in the position of the particle if mv is known very accurately.

For the use of wave-groups (as Bohr states) is necessarily accompanied by a lack of sharpness in the definition of period and wave-length, and hence also is the definition of the corresponding energy (E) and momentum (P) as given by the relation

$$E/\nu = P\lambda = h.$$

Rigorously speaking, a limited wave-field can be obtained only by a superposition of a manifold of elementary waves corresponding to all values of ν. But the order of magnitude of the mean difference between these values for two elementary waves in the group is given in the most favorable case by the condition

$$\Delta t \Delta \nu = \Delta x \cdot \Delta \sigma = 1.$$

From this relation Heisenberg's principle follows directly on multiplying both sides by the constant h.

From this discussion it is perhaps evident to the reader why it is that the matrix calculus with its irrational variables and the wave mechanics with its imaginary wave-packets to represent actual particles, both lead to the same conclusions. It is the existence of the Principle of Indeterminism that really ties them together philosophically.

(To be concluded)

[4] Bohr, *Nature*, **121**, 850 (1928).

It is hope which maintains most of mankind.—SOPHOCLES.

THE INSTITUTE OF METALS. ITS ORIGIN AND OBJECTS

RICHARD SELIGMAN, THE INSTITUTE OF METALS, 36 VICTORIA STREET, WESTMINISTER, LONDON, S. W. 1, ENGLAND

At the request of the editor I write a brief description of the Institute of which I have the honor to be president for the current year.

The Institute of Metals was founded in 1908 and the first general meeting was held in November of that year in the City of Birmingham, England, which may well be called the center of the non-ferrous metal industry of Great Britain. To my American readers it will be significant that one of the first items on the agenda of that inaugural meeting was the reading of a letter of enouragement and welcome from the American Brass Founder's Association. The letter was signed by Mr. W. M. Corse, who for twenty-two years has remained one of the staunchest friends of our Institute and is now the honorary corresponding member to the Council for the United States of America.

At the time of the foundation of the Institute of Metals, there was only one national body in Great Britain wholly devoted to the study of metals, the Iron and Steel Institute. This old-established organization had for close on forty years played an important rôle in fostering the interests of those connected with metallurgy of iron but by its constitution it was ill-adapted to offer similar service to those engaged in non-ferrous metallurgy. It was to fill the gap thus left that the new Institute was called into existence, its most active sponsors being the late Mr. W. H. Johnson, the late Sir William White, at that time chief constructor to the British Admiralty, and Dr. (now Sir Harold) Carpenter, F.R.S., then of Manchester University. These three names very aptly illustrate one of the guiding principles which its founders gave to the new organization, for the first was that of a man wholly engaged on the business side of non-ferrous metals; the second was that of a great engineer and user of these metals; while the third name is known throughout the world as that of a leading scientist who has made the study of metals his life work. It was appropriate, therefore, that one of the first rules of the Institute, and a rule, moreover, which has remained unaltered to this day, should state that membership is confined to those engaged in the manufacture, working, or use of metals and alloys or to those of scientific, technical, or literary attainments interested in metals.

The objects of the Institute were clearly laid down from the start and they too have remained substantially unaltered by the lapse of time. They are described as follows in the earliest rules of the Society.

1. To afford a means of communication between members of the non-ferrous metal trades upon matters bearing upon their respective manufactures, excluding all questions connected with wages, management of works, and trades' regulations.

2. To arrange periodical meetings for the purpose of discussing practical and scientific subjects bearing upon the manufacture, working, and use of the non-ferrous metals and their alloys.

THE INSTITUTE OF METALS LOCATED AT 36 VICTORIA STREET, LONDON, ENGLAND

3. To advance the knowledge of metals and alloys, *e. g.*, by the publication of a journal containing both original papers and abstracts of publications relating to these subjects, and in any other way.

How fully these objects have been attained and how great an influence their attainment has had on non-ferrous metallurgy I shall hope to show in the course of these lines.

Before proceeding it is necessary to say that the founders of the Institute approached their task not without diffidence. Those who would add a new scientific society to the list which even twenty-two years ago seemed to many of us overlarge must be very certain that it will fill a definite need and there were not wanting those who urged on the promoters that they were courting failure. It was feared that insufficient support would be forthcoming, owing to the scattered nature of the non-ferrous industry and the diversity of the metals with which it is called upon to deal; that active opposition might be expected from the older and more firmly established body and finally that sufficient work would not be available to justify the creation of a separate Institute.

These forebodings have been disproved by experience. In each and every case the founders lived to see their faith amply justified and their critics confounded. Let us consider first the support which the Institute has won for itself. The original list of members contains some 250 names. Today, despite the ravages of four years of warfare, despite the hardships and disorganization which the twelve post-war years have brought to a distracted world, the roll of the Institute carries close on 2200 names, and among them those of the most distinguished metallurgists throughout the civilized world. So much for the support which has been accorded to our Institute. As to the hostility of the older body devoted to the study of metals, it is safe to say that there has never been a sign of such a feeling. When the Institute of Metals was founded it was clearly recognized that its objects were in many respects different from those of the older society, not only because it was to study other metals but because its methods of study were expected to be very different. Whether those differences exist in full measure today as they undoubtedly did twenty-two years ago, whether even the rigid classification of metals into ferrous and non-ferrous can still be maintained, are questions we need not approach here. It may, however, be well to say that there are many among us who think that the time is not far distant when some of the steps taken might well be retraced and that closer relations between the two Institutes could be established without doing violence to the interests of either. In the meantime both organizations work together in the greatest amity wherever their coöperation is advantageous. For instance, the societies will be paying a joint visit to Canada and the United States in 1932, and even more noteworthy is it that my immediate predecessor, Dr. Walter Rosenhain, F.R.S., while

still occupying the chair of the Institute of Metals was selected to be the recipient of the highest distinction in the gift of the Iron and Steel Institute, the Bessemer Medal.

Now as to the work which the Institute of Metals has found ready to its hand. Reference need only be made to the 43 volumes in which its proceedings are recorded to make it clear that there has been no dearth of useful activity. Those volumes are packed with the records of research, with lectures and addresses covering not only the whole field of non-ferrous metallurgy, but describing in succinct and readable form the latest advances in many cognate fields of scientific endeavor. For it is one of the many useful activities of the Institute of Metals to invite each year some distinguished scientist to deliver the "May Lecture" to the members, his subject being akin to but not necessarily identical with their own. There is no need to give here a list of the May lecturers, in which figure such names as Sir J. J. Thomson, Sir William Bragg, Professor T. Soddy, Sir Ernest Rutherford, Professor Lorentz.

It would be quite impossible to give in a short review such as this even an outline of the original work recorded in the volumes of the Institute's *Journal*. It must be remembered that the life of the Institute coincides with a period of intense activity in the study and development of non-ferrous metals, the elucidation of the structure of metals and alloys, the perfecting of new combinations and the improvement of the properties of old combinations, new methods of production, and new methods of fabrication. Many of these advances have been first described at meetings of the Institute of Metals, have been the subject of animated discussion by word and correspondence, and have been published in the *Journal of the Institute*. A glance at the list of original contributions published by the Institute in the year 1929 will give a good idea of the wide range of subjects with which its members deal and of the value of the *Journal of the Institute* as a means of bringing the advance of non-ferrous metallurgy to the notice of those most concerned. We find in all 32 communications. Of these nearly half deal with practical problems of immediate importance to industry and covering such widely differing subjects as melting furnaces, electrodeposition of metals, casting defects, and the corrosion of metals by water, air, and furnace gases. Of the remainder, some seven or eight papers deal with the constitution of alloys, several with methods of investigation, one with the metals of antiquity and one, the May Lecture by Sir Oliver Lodge, with such a general subject as the "States of Mind Which Make and Miss Discoveries."

Apart altogether from these complete records a large section of the *Journal* is devoted to the presentation of abstracts of the publications of other bodies. These abstracts are prepared with great diligence and are recognized as giving the most complete picture available of the work being

done in non-ferrous metallurgy throughout the world. They serve also to keep metallurgists, whether engaged in ferrous or non-ferrous metallurgy, in touch with the progress of their art for they describe very fully the advances in methods and manipulation common to both branches.

In addition to the activities already touched upon, the Institute has played a prominent part in many important questions. It was responsible for many years for the organization and prosecution of a series of researches on the corrosion of non-ferrous metals, researches still in progress and still directed, although under different auspices, by one of its founders and past presidents, Sir Harold Carpenter, F.R.S. It has collected and made available to its members a valuable library of books and periodicals dealing with non-ferrous metallurgy and has organized an Information Bureau of which its members and others are taking more and more advantage. The Institute is interested in many educational institutes and the services of its members are frequently asked for and always forthcoming on the advisory committees which control some of our leading schools of metallurgy. The Institute always takes an active part in the international congresses which play so important a rôle in the advance of modern science.

Now a few words on the organization of the Institute. From its earliest years the Institute of Metals has been organized on an international basis. Among its original members were a number from overseas and this number has grown steadily as the value of its work has been recognized, until today the overseas members number well over 800 or some 40% of the whole, 300 of whom reside in the United States. This factor has brought many problems in its train and it is a subject of continuous consideration by the Council which controls the activity of the Institute how the interests of these overseas members may best be served and promoted. Touch is kept between the Council and its overseas members by the agency of corresponding members, fourteen of whom now place their valuable services at the disposal of the Council. In Great Britain there are a series of local sections centered in our largest industrial areas. Each of these local sections meets about six times a year for the presentation and discussion of papers and serves as a useful training ground for the younger members.

The general meetings of the Institute take place three times a year. The first or spring meeting is always held in London and is opened by a short business session at which the report of the Council, the accounts and other similar matters are discussed. This is followed by the reading of papers and their discussion while every other year the incoming president delivers his presidential address. The spring meetings last for two days and are the occasion of the most important social gathering of the year, the annual dinner. By no means the least important of the Institute's activities are the social gatherings of members and their friends and it has been well said that at these functions "personal contacts have often been made which have

led to future benefits for all concerned, whether of a business, industrial, or scientific nature," and again "perhaps some of the most useful discussions are those which take place among small groups of members" during the informal gatherings.

Of the May meeting I have already written. Only one evening is devoted to the reading of the May lecture but again advantage is taken of the presence of a number of members for informal entertainment and friendly discussion.

The autumn meeting, the third and last general meeting of the year, is held early in September, and unlike the other two is a wandering function, being held now in this city, now in that. Nor is the meeting place confined to Great Britain. With the continual growth in the number of overseas members it has been found desirable to promote intercourse between the British members and their overseas colleagues by arranging for occasional meetings abroad. Belgium and Germany have already acted as our hosts and foreign visits have been arranged to Zürich in Switzerland for 1931 and to the United States and Canada in 1932. Experience has shown that these visits are very popular among both the home and overseas members and last year's meeting at Düsseldorf was attended by 300 from no less than 18 different countries, an eloquent testimonial to the international character of the work we are doing.

The autumn meeting, like the spring meeting, is devoted in part to the reading and discussion of papers and in part to social functions but a feature is always made of visits to the metallurgical institutions in the neighborhood as well as to places of general interest.

It would be impossible to close an account of the Institute of Metals without referring, however briefly, to the secretariat upon which falls the brunt of the work of maintaining the efficiency and progress of this remarkably active body. To the devoted labors of the small band of workers which form our secretarial staff a great part of the success we have achieved is due.

That success is no small matter. As already stated the life of the Institute has coincided with a period of intense activity in the study and development of non-ferrous metallurgy, but those of us who are best placed for knowing the facts do not believe that this has been mere coincidence. We believe rather that by bringing together the workers in many fields, by giving them opportunities for intercourse one with the other, by providing a forum in which difficulties can be discussed, new problems raised, old problems solved, by drawing within its sphere metallurgists from all over the world and by repaying their allegiance with willing service, the Institute of Metals has itself stimulated that activity, has rendered it more fruitful, and has thereby fulfilled the objects of its founders and promoted in no small measure the triumphant advance of non-ferrous metallurgy.

THE FAILURE OF AN ANTITHESIS BETWEEN MATTER AND ENERGY*,†

ALPHEUS W. SMITH, THE OHIO STATE UNIVERSITY, COLUMBUS, OHIO

In any attempt to describe and interpret physical phenomena in a way which can be verified by experiment it is necessary to isolate certain invariants or basic entities whose characteristic properties do not change from time to time. A very limited consideration of physical phenomena suggests that inorganic bodies such as silver or gold possess a certain number of unchanging characteristics which are essentially invariant. These basic characteristics persist when a solid changes to a liquid or a gas, or when a gas changes to a liquid or a solid. These unchanging characteristics were gathered together and called the characteristics of matter. Hence in classical physics the word matter became a term to cover a rather loosely defined set of properties about which there was insufficient detailed information. Whatever in the end might prove to be the essential characteristics of matter as thus defined, it was sufficient at the outset to know that gross matter was an invariant in terms of which large-scale physical phenomena could be clearly and accurately described.

It was early observed that matter under certain conditions could acquire new properties which were not apparently included in its basic definition. It was as if a new entity had been superposed upon or introduced into matter. For example, a ball in falling from the top to the bottom of a tower was observed to acquire a set of properties which had not in any way been attributed to the ball when it was at rest. When the behavior of the air at rest was contrasted with its behavior in motion, it was evident that an entirely new set of characteristics had arisen by virtue of this motion. It was found that the additional phenomena arising in such cases could be quantitatively described in terms of an additional entity called *energy*. In the beginning there was no detailed information concerning the fundamental characteristics and properties of energy. All such characteristics were grouped together under a single term with the emphasis on the fact that this entity, known as energy, was altogether essential for an accurate description of physical phenomena.

Matter was conceived of as continuous and energy was likewise thought of as continuous. There was no thought about any fine-grained structure that might be present in either matter or energy. For a description of large-scale physical phenomena it was sufficient to consider the quantity of energy and matter associated with the system. Matter was regarded

* An address given before the Physical Science Section of the Tenth Ohio State Educational Conference, held in Columbus, April 3, 4, and 5, 1930; and printed in the *Proceedings*.

† This address is also substantially the lecture given by the author as reported in "An Experiment in Coöperative Teaching," by EVANS and DAY, J. CHEM. EDUC., 5, 1133 (Sept., 1928), and by PHOEBE PAINE on "The Nature of Matter," *Ibid.*, p. 1135.

as distinct from energy and energy as entirely distinct from matter. None of the characteristics of energy could be attributed to matter and none of the characteristics of matter could be attributed to energy. There was a complete antithesis between matter and energy. Energy might reside in matter but it could not share any of the properties of matter. There could be no interaction between matter and energy. Both matter and energy must be conserved. There was a law of conservation of energy and a law of conservation of matter. Neither matter nor energy could be created or destroyed. Matter could not increase at the expense of energy nor energy at the expense of matter. Energy could not be transformed into matter nor matter into energy. The antithesis between the two entities was complete. For large-scale physical phenomena this view is thoroughly satisfactory.

A more detailed study of physical phenomena showed that a great many physical phenomena like the pressure of a gas or the law of multiple proportions could find an explanation only on the basis that matter is made up of discrete grains or particles called atoms or molecules. With this hypothesis many otherwise obscure physical and chemical phenomena become quite understandable. But the subdivision of matter was not to stop with the atom or molecule. Small indivisible atoms were not to be the limit of man's imagination in the analysis of the fine structure of matter. A still more penetrating study of physical phenomena and the accumulation of a wealth of new data showed that atoms must be thought of as made up of indivisible units of positive and negative electricity, known as protons and electrons. These electrons and protons become the two building materials out of which all atoms are composed. One type of atom thus differs from another type only in the number and arrangement of protons and electrons in its interior. It is as if there were only two building materials out of which to build all kinds of architecture, whether cottages or cathedrals. This extraordinary subdivision of matter into smaller and smaller units has revealed new and unsuspected relations between matter and energy.

On the other hand a more careful study of the nature of energy and the laws which govern its behavior has revealed the significant fact that energy can no longer be considered as continuous but that it must be thought of as made up of small indivisible units called quanta. For example, the radiation received from the sun is more like a rain of small particles or droplets than like a continuous stream. These grains of energy vary in size according to the wave-length of the radiant energy. The amount of energy associated with each corpuscle of energy is greatest where the frequency of radiation is greatest and least where the frequency of radiation is least. For example, a quantum of energy in the case of X-rays is great in comparison with a quantum of energy in the case of

ordinary red light. Hence, the radiation from a hot body like the sun behaves like a mist in which there are particles of all sizes rather than like a shower in which the drops are of uniform size. Many important and conclusive types of evidence have made it necessary to accept this view concerning the nature of radiation. The accurate description which this theory gives of the distribution of spectral lines in the different series of the hydrogen spectrum is only one of the many convincing types of evidence available for this view of the nature of radiation.

Since both matter and energy exist in the form of very finely divided grains it becomes of interest to see whether matter in these small units called electrons, may not after all interact in some way with the smallest units of energy, *i. e.*, with a quantum of energy or a photon. The scattering of X-rays by electrons showed that when one of these bundles of energy strikes an electron, the bundle of energy and the electron behave at collision as two small steels balls would behave at collision. In other words the laws which govern the collision of a unit of energy and a unit of matter are precisely the laws which govern the collision of two small units of matter. Hence, these fundamental experiments disproved the time-honored assumption that there could be no interaction between units of matter and units of energy—the assumption that energy and matter have no characteristics in common and that there can be no interaction between them.

The breaking down of the antithesis between matter and energy did not stop here. When one proton and one electron are assembled to give an atom of hydrogen, the mass of the hydrogen atom is found to be 1.008. Now when four electrons and four protons are assembled to give an atom of helium the mass of the helium atom is not four times the mass of the hydrogen atom but it is less than four times the mass of the hydrogen atom, that is, the mass of the helium atom is not 4.032 as one might expect but it is just 4. If four white marbles and four black marbles are collected they always weigh four times as much as one white marble and one black marble. By the same reasoning one must expect that the mass of four protons and four electrons would be just four times as much as the mass of one proton and one electron. But the result is different in this latter case. Now what has become of this additional mass? It has been radiated as energy so that we have a case where mass is transformed into energy. Many similar cases have been shown to exist. Hence we must no longer say that matter cannot be transformed into energy. There is no longer a law of conservation of matter and another law of the conservation of energy. These two laws have been replaced by a single law, the law of conservation of both matter and energy. The two together must be conserved but not each separately. When matter disappears energy appears and it may be true that energy may in some

cosmic processes disappear and matter be formed in its place. Thus one more fundamental distinction between matter and energy must be abandoned.

It is not alone in these relations, important as they are, that the complete antithesis between matter and energy has proved to be without validity. In another and still more surprising manner the contrast between energy and matter has been disproved. It is one of the fundamental tenets of the classical theory that light behaves as a wave motion. To provide a suitable medium in which these waves could travel, physicists like Kelvin created a hypothetical ether with properties suitable to account for the behavior of light as a wave motion. The simplest and most fundamental experiment on which the concept of light as a wave rested was the classical experiment of Young in which it was shown that two rays of light of the same wave-length could be superposed in such a way that the intensity would be either increased or decreased. When light coming from two identical sources fell on a screen there was a succession of bright and dark lines. The bright lines occurred, when the paths of the two beams differed from each other by a whole number of wave-lengths of the light and the dark lines occurred when the paths differed from each other by an odd number of half wave-lengths of the light. Thus two lights of identical wave-lengths had the power to either reënforce or destroy each other. Such experiments found their easiest interpretation by saying that light is a wave motion and that under suitable conditions the crest of one wave may fall exactly upon the crest of another wave and thus cause the resultant crest to be higher than the crest of either wave alone or that in other cases the crest of one wave may fall upon the trough of another wave so that the two waves just neutralize or destroy each other with the result that there is no resultant disturbance in the medium.

From observations on the distance between the bright and dark lines on the screen it is possible to calculate the wave-length of the light incident on the screen. Now here is a characteristic of radiant energy that seems unlike any characteristic that might be attributed to matter even in the most finely divided state. But in the recent work in physics it has been found that light does not always behave as if it were a wave motion. In many cases it behaves as if it were made up of a shower of finely divided particles or corpuscles. Hence our confidence in the wave character of light is not so great as it formerly was and we are accustomed to say that light sometimes behaves like waves and that it sometimes behaves like finely divided particles. Now since light is dual in character, that is, it sometimes behaves like particles and sometimes behaves like waves, we should look more critically at matter, which until recently was universally accepted as behaving like finely divided particles. There is the possibility that this duality, that is, sometimes particles and sometimes

waves, is more widely spread than had been suspected. There is a possibility that matter may sometimes behave as if composed of waves although it, in most cases, behaves as if composed of particles.

Making the bold assumption that particles of matter, for example, an electron, have the characteristics of waves, de Broglie worked out the relation between the mass of the particle, its velocity and its wave-length. As either the mass or the velocity of the particle changes, its wave-length also changes, but when both the mass and the velocity are known the wave-length can be calculated. Following the theoretical developments of de Broglie in France and Schrödinger in Germany, Davisson and Germer at the Bell Telephone Laboratories, and Professor G. P. Thomson at the University of Aberdeen have been able to devise ingenious experiments which show that a beam of electrons or an individual electron behaves as if composed of a succession of very small waves. They showed that one beam of electrons would interfere with another beam of electrons having the same velocity and produce interference effects which are in all essentials equivalent to the interference effects observed in the case of a beam of light. From these interference patterns they calculated the wave-length of the electrons which composed the beam. The wave-length necessary to account for their observations was in agreement with that deduced by de Broglie. From such an experiment one must conclude that a beam of particles of matter can produce interference effects like those produced by light waves or light corpuscles. These experimental and theoretical considerations indicate that a particle of matter must be considered as made up fundamentally of a series of wavelets or it may be assumed that each particle has a series of wavelets associated with it and that these wavelets determine the path along which the particle can travel. Consequently the particle has a two-fold character. It is either the center of a series of wavelets or a series of wavelets have the properties formerly attributed to a particle. Hence matter on more careful analysis has in some cases some of the characteristics of wave motion. In other cases it has the characteristics of particles. Hence this dualism which showed itself in energy shows itself again in matter. Both energy and matter behave as if they were composed of waves or as if they were composed of particles. You can measure the wave-length of light rays but you can also measure the wave-length of the electrons in a beam of electrons. You can count the number of electrons and you can count the number of grains of energy in a beam of light. Here again the distinction between matter and energy disappears.

With these newer ideas concerning the nature of energy and matter, there has also come an important modification of the meaning to be attached to the explanation of physical phenomena. An intensive study of subatomic physics has shown that the rules and laws of classical physics

can be considered as only valid for macroscopic phenomena. They do not hold for microscopic phenomena. The ordinary laws of mechanics are not valid inside the atom. A new set of mechanical relations known as quantum or wave mechanics describes the behavior of electrons, protons and photons inside an atom. These rules and laws bear the same relation to subatomic physics that the laws of classical mechanics bear to large-scale phenomena like celestial mechanics. However, for macroscopic phenomena the laws of quantum mechanics are the same as the laws of classical mechanics. There is, however, always this important difference. The physicist of the classical period was interested in finding some kind of causal relation by means of which to explain the observed phenomena. He tried to make some kind of mechanical model by which he could understand his observations. In subatomic physics such a procedure is impossible. Mechanical concepts are not available and ordinary mechanical laws are not valid. The new rules known as quantum mechanics do not express causal relations. They simply state the rules according to which subatomic phenomena occur. The conception of causality is eliminated. The new rules are essentially statistical laws in which probability plays a major part.

A LECTURE EXPERIMENT IN SURFACE TENSION

WILLIS A. BOUGHTON, HARVARD COLLEGE, CAMBRIDGE, MASSACHUSETTS

Mercury ordinarily can be made to wet glass only with great difficulty, if at all, when both are clean and dry. Some of the complex liquid amalgams, however, are capable of wetting clean, polished glass surfaces and forming on them temporarily adherent films. Such films are usually immediately destroyed when wet with aqueous solutions, or allowed to come in contact with acid vapors such as that of hydrogen chloride.

Directions: Prepare a complex liquid amalgam by melting in a clean 50-cc. porcelain casserole 10 g. of solder (50–50), 10 g. of Wood's metal and 5 g. of zinc, and adding when somewhat cooled 180–250 g. of pure mercury, at first slowly with a medicine-dropper pipet. This mixture is fluid when cold and easily wets the side of the casserole. Transfer the cold amalgam to a grease-free, well-washed, clean and dry 10 cm. crystallizing dish and swirl to cover the bottom completely. Carefully drain the excess of liquid back into the casserole. The bottom of the dish should now be covered with an opaque, mirror-like film of amalgam.

Hold the dish vertically back of the mouth of an opened bottle of concentrated hydrochloric acid. Blow carefully across the mouth of the bottle toward the mirror. The moist acid fumes instantly break up the film, causing the amalgam to gather into drops and rendering the bottom of the dish transparent again.

THE TEACHING OF THE PHASE RULE IN COURSES IN ELEMENTARY PHYSICAL CHEMISTRY

H. LEE WARD, WASHINGTON UNIVERSITY, ST. LOUIS, MISSOURI

There is perhaps no topic, included in the course in elementary physical chemistry, that is more difficult to treat satisfactorily than the phase rule. In the first place the rigorous derivation of this rule requires a much more thorough treatment of the laws of thermodynamics than it is practicable to give in the beginning course. In most texts no attempt is made at even an approximate derivation and the rule is merely stated. In Findlay's book (*1*) only a very brief derivation is given and the reader is referred to works on thermodynamics. As a result of this procedure, the student is compelled to memorize the rule and use it with little knowledge of its real significance. Moreover, he does not connect the rule with any of the equilibrium equations which he has previously studied, such as the equation of state for gases, the various forms of the distribution law and the law of mass action. Also, since the phase rule has not been derived and the fundamental assumptions upon which it is based clearly stated, there is much chance of the rule being used in cases where it is not valid. Finally, the application of the simple form of the rule is fraught with difficulty owing to uncertainty in the determination of the number of components in the system studied.

While there is nothing essentially new in the treatment here described it is hoped that it may obviate the above difficulties to some extent. The derivation is by no means rigorous but it is in a form which may easily be used in a beginning course in physical chemistry. The author has so used it for a number of years.

It is first necessary to examine rather carefully the terms which will be used in the ensuing discussion of the phase rule. Such terms are system, property, variable, and phase. Others will be more satisfactorily considered later.

The term system refers to that part of the physical world chosen for consideration. It may be small or of great extent. It may be separated from the rest of the world by definite boundaries, such as the walls of a tube or flask, or the boundaries may be entirely imaginary.

The properties of a system are those experimentally measurable quantities which serve to distinguish a system or a part of a system from other systems or parts of the same system. Moreover, for consideration in the present case, the further restriction must be made that these properties are independent of the size and shape of the system. In other words, the only properties considered are the so-called intensive ones. For example, the mass of a system depends partly on its size and is therefore an extensive property, while the mass per unit volume is an intensive one. Temperature, pressure, refractive index, etc., are independent of the size and shape of the system and are clearly intensive properties. Since the measurement

of properties is the only way we have of distinguishing between systems and different states of the same system, we may consider that the properties determine the identity or difference between systems and the variations in the states of the same system. As the accuracy of the measurement of properties increases, the ability to distinguish between systems or different states of the same system also increases. Therefore, two systems may be considered identical when all their properties are identical within the limits of experimental measurement.

Variables are those conditions which if changed will produce variations in the properties of the system. For example, changes in the temperature, the pressure, the composition of the system, gravitational, electro-magnetic and electro-static fields will evidently change the properties of the system and therefore may be considered as variables.

Since the phase rule is used to describe the behavior of heterogeneous systems it is necessary at this point to define the term phase. In the first place a phase must be homogeneous. This means that samples taken from different regions of the same phase will show identical compositions and intensive properties and these are independent of the size of the sample taken for observation. Thus a colloidal solution is not a single phase system if by means of the ultramicroscope we are able to distinguish the particles of the disperse phase, while a true solution is considered to be a single phase system, since we are unable, by direct experiment, to obtain evidences of heterogeneity. In addition a phase must have definite boundaries and be separable by mechanical means from other phases. By the latter criterion a colloidal solution would be considered as heterogeneous when it is possible to separate the disperse phase by gravity or centrifugal force. It is plain from the above examples that the distinction between a one-phase and a two-phase system is not always sharp. Since the phase rule does not apply to the borderline cases, as will be later shown, it is unnecessary to consider them further in this place.

It should be clearly understood that the phase rule properly applies only to those systems which are in a condition of stable equilibrium. If this were not the case, it is evident that the same system might have its properties varying with the time when the variables, such as pressure and temperature, etc., were constant. The criterion for equilibrium is that the system shall not have the possibility for change with time without the gain or loss of energy by the system. In thermodynamic terms this is indicated by the system having a minimum free energy or a maximum entropy. The rule is often applied to conditions of metastable equilibrium. This means that the properties of the system do not change appreciably in the time of observation but have the possibility of such change, that is, their free energy is not a minimum. The possibility of such relatively stationary states in metastable equilibrium is best considered under the

various equilibrium equations rather than from the point of view of the equilibrium as a whole.

The principle here employed for the deduction of the phase rule is to find the total number of variables which may determine the properties of the system and to subtract from this the number of independent equations involving these variables, thus ascertaining the number of variables whose values must be fixed in order to determine completely the properties of the system.

In ascertaining the total number of variables which are to be considered, it is necessary that those chosen shall determine completely all the properties of the system. This is, of course, entirely an experimental question. We find by experiment that the density of a solution is determined by the temperature, by the composition of the solution and by the imposed external pressure. This relationship is found to be quite general for systems of a single phase. Exceptions occur and they will be discussed later. In systems of more than a single phase, the properties of each phase are different and depend, as is shown by experiment, on the pressure, the temperature, and the composition of the phase under consideration. At equilibrium the temperature and the pressure of each phase are usually the same but the phase compositions are not. The variables chosen are therefore the temperature, the pressure, and the composition of each phase. The usual method of expressing composition of a homogeneous mixture or solution is in terms of concentrations, that is, the number of grams or mols of the various chemical individuals for a given volume of the phase. Such chemical individuals will be designated molecular species although it is not necessary that the molecular weight be known. For example, liquid water probably consists of several different kinds of molecules whose exact formulas and proportions are not known but water may be regarded as a single molecular species. The primary variables employed in the present discussion will consist of the temperature, the pressure, and the concentration of each molecular species in each phase. Other methods of expressing the compositions of the various phases might be chosen such as weights, per cent or mol fractions, but in those cases the treatment is not quite so simple.

The equations involving the primary variables chosen above are of three types, all of which have ordinarily been presented to the student previous to a discussion of the phase rule. The first of these is the equation of state which connects the values for the volume, pressure, and temperature of a single phase of fixed composition. The most familiar forms are the perfect gas equation and the equation of van der Waal's, the latter applying to liquids as well as gases. The exact form of this equation of state may not be known, but all specific gravity tables are based on the assumption that the volume of a given mass of a pure substance or a solution is deter-

mined by its temperature and the pressure imposed upon it. We may therefore safely assume that an equation or state exists for each phase of a definite composition.

At first sight it may seem unnecessary to include an equation involving volume as a function of temperature and pressure when the volume is not chosen as one of the variables of the system. The reason for such inclusion is that a volume determination is always necessary for the determination of concentration as defined above. In case the constitution of the phases had been expressed in weight per cent or mol fractions it would have been necessary to substitute another type of equation for the equation of state.

A second type of equation gives the relationship between the concentrations of a single molecular species in two phases which are in equilibrium with one another. This will be designated a distribution equation. The so-called "Distribution Law" which connects the concentrations of a substance in two liquid phases in equilibrium with one another is merely a special case of the more general relationship. Others laws which belong to this type are those of Raoult and Henry, which govern the distribution of a substance between a liquid and a gaseous phase. In the three instances cited above the relationship between the two concentrations is a simple proportional one. It is not at all necessary that the relationship be so simple or even that it be known. The general law might be stated: the concentration of a given molecular species in a certain phase is some function of the concentration of the same molecular species in another phase in equilibrium with the first, the temperature and the external pressure being constant.

The third type of equation is that for chemical equilibrium; namely, the law of mass action which gives the relationship between the concentrations of the molecular species concerned in a chemical reaction taking place in a single phase. It might be considered that there would be as many expressions of this type as there are phases, but it is probable in most cases involving chemical reaction that the process takes place with considerable velocity in only one phase. Moreover, at equilibrium the concentrations of the factors and products in that phase are connected with the concentrations of the same constituents in all of the other phases by distribution equations. As a consequence a mass law equation could be deduced for each phase by means of the mass law expression for a single phase and the various distribution equations. Therefore, the mass law expressions for all except one phase are dependent equations and are not considered. There are, therefore, only as many mass law equations as there are chemical reactions taking place in the system.

It might be argued that in many cases the usual form of the mass law, involving the concentrations as variables, does not hold. This does not

invalidate the proof since analogous expressions involving functions of the concentrations, *i. e.*, the activities, does hold in all cases. It is well to point out that, in case the student is familiar with the use of the activities and activity coefficients, a much more rigorous derivation of the phase rule may be made by the same general method as is here employed. Since most elementary texts do not treat the above functions fully, it does not seem advisable to include such a derivation in the present paper.

The next procedure is to find the number of variables which must be assigned definite values in order to completely determine all of the properties of a system consisting of a given number of molecular species in a given number of phases. This number is designated the number of degrees of freedom of the system. There are two methods of accomplishing the above result. One is to derive the general case for a system consisting of N constituents in P phases, which gives with slight modification the usual form of the phase rule. The other is to determine the number of degrees of freedom in each particular case by subtracting the number of independent equations connecting the variables from the number of variables. The author has found the latter procedure much more satisfactory in elementary courses since it focuses the student's attention upon the fundamental concepts upon which the phase rule is based and with which he should already be familiar. The latter method will therefore be treated first.

The procedure involves a consideration of systems of one or more molecular species in various possible numbers of phases. The systems will be chosen in such a manner as to bring out the main points which are important for an understanding of the phase rule. The systems treated appear in the table and will be referred to by their numbers which appear in the first column. The numbers of molecular species and phases appear in the next two columns and the variables in the fourth. The temperature of the system and the pressure imposed upon it are assumed to be uniform throughout the system and each molecular species is supposed to be present in each phase even though the amount may be very small. For systems of a single molecular species (Cases 1–3) the density is used in place of the concentration and the subscripts indicate the different phases. For Cases 4–8 the subscripts also indicate the various phases and the prime symbol indicates the second molecular species. In the other examples the number of concentration variables is obtained by multiplying the number of molecular species by the number of phases. The fifth, sixth, and seventh columns of the table indicate the number of independent equations connecting the variables classified as equations of state, distribution equations and law of mass action expressions for a chemical reaction. The last column gives the number of degrees of freedom and is obtained by subtracting the total number of independent equations from the number of variables.

TABLE I

Case No.	Molecular species	Phases	Variables	Equations of State	Equations of Distribution	Chemical	Degrees of freedom
1	1	1	$T.P.d$	1	0	0	2
2	1	2	$T.P.d_1d_2$	2	1	0	1
3	1	3	$T.P.d_1d_2d_3$	3	2	0	0
4	2	1	$T.P.\frac{C_1}{C_1'}$	1	0	0	3
5	2	2	$T.P.\frac{C_1,C_2}{C_1',C_2'}$	2	2	0	2
6	2	3	$T.P.\frac{C_1,C_2,C_3}{C_1',C_2',C_3'}$	3	4	0	1
7	2	4	$T.P.\frac{C_1,C_2,C_3,C_4}{C_1',C_2',C_3',C_4'}$	4	6	0	0
8	2	4	$T.P.\frac{C_1,C_2,C_3}{C_1',C_2',C_3',C_4'}$	4	5	0	0
9	2	2	$T.P.$ 4 concentration terms	2	2	1	1
10	3	2	$T.P.$ 6 concentration terms	2	3	1	2
11	3	3	$T.P.$ 9 concentration terms	3	6	1	1
12	4	3	$T.P.$ 12 concentration terms	3	8	1	2
13	4	1	$T.P.$ 4 concentration terms	1	0	1	4
14	5	1	$T.P.$ 5 concentration terms	1	0	2	4
15	6	1	$T.P.$ 6 concentration terms	1	0	2	5
16	2	2	$T.P_1,P_2$ 4 concentration terms	2	1	0	4

For Case 2 it is evident that since two phases are present there is a distribution for the single molecular species between these phases which involves one distribution equation. The fact that there are only two independent distribution equations (Case 3) for a single substance present in three phases is by no means so evident. Suppose the simple proportional form of the distribution equation to hold for all possible distributions. Let the concentrations (or densities) in the three phases be C_1, C_2, and C_3 and the constants in the distribution equations be K_1, K_2, and K_3. Then the three possible equations are $C_1 = K_1C_2$, $C_2 = K_2C_3$, and $C_1 = K_3C_3$. Only two of these equations are independent since any one may be deduced from the other two. For example, substituting the value of the C_2 from the second equation in the first equation, we have $C_1 = K_1K_2C_3 = K_3C_3$. In general, there is always one less distribution equation for each molecular species than there are phases in the system. This means that the total number of distribution equations is the number of molecular species multiplied by one less than the number of phases.

It is plain from Case 3 of the table that a system of a single constituent in three phases has no degrees of freedom, that it is stable at a single definite temperature and pressure and each phase has a definite density. A simple calculation shows that if four phases should be present the number of degrees of freedom would be negative, indicating that such a system cannot

exist in a state of equilibrium, a deduction in accord with experience. The instructor should give numerous concrete examples of systems with but a single constituent such as water, sulfur, etc.

Cases 4 to 7 show the possibilities for systems of two constituents which do not involve a chemical reaction. A maximum of four phases may be in equilibrium, a common example being the eutectic mixture. If a given molecular species is not present in one phase, the number of concentration terms is diminished by one but at the same time there is one less distribution equation and the number of degrees of freedom remains the same as appears in Cases 7 and 8. It is therefore simpler to consider each molecular species to be present in each phase though the amount may be small.

The effect of a chemical reaction in which one molecular species is in equilibrium with another is shown in Case 9 as compared with Case 5. Since there is one more equation and the number of variables is the same, the number of degrees of freedom is reduced by one.

Only special cases in which the number of molecular species exceeds two will be considered. Case 10 illustrates the behavior of solid ammonium chloride in equilibrium with its vapor, which is, to a large extent, dissociated into ammonia and hydrochloric acid as is shown by gas density experiments. There are, therefore, three molecular species present in two phases and the degrees of freedom come out two. It is a well-known fact that ammonium chloride gives a perfectly definite vapor pressure at a given temperature, indicating but a single degree of freedom. The reason for this is that if only ammonium chloride be present at the start, the ammonia and hydrochloric acid are produced in equivalent quantities and, therefore, the concentrations of the two latter substances in the vapor phase are connected by an equation and this cuts down the degrees of freedom by one. If, however, there is present an excess of ammonia or hydrochloric acid the system has two degrees of freedom as indicated in Case 10. Also if either the ammonia or the hydrochloric acid was soluble in the solid ammonium chloride the system would have two degrees of freedom, since the concentrations of the acid and ammonia in the vapor phase would not have been equivalent in spite of the fact that they were produced in equivalent quantities.

The system used in lime burning, calcium carbonate–calcium oxide–carbon dioxide, is shown by Case 11. Here there is but a single degree of freedom, and at a definite temperature the pressure of gaseous carbon dioxide would have a fixed value independent of the amount added, provided only both calcium carbonate and calcium oxide be present.

In the above cases we have tacitly assumed that the only substances present were calcium carbonate, calcium oxide, and carbon dioxide. Suppose that the system also contains nitrogen. The total number of molecular species is four and there are two degrees of freedom as appears in Case 12. This means that at a definite temperature the total pressure

might have any value depending on the amount of nitrogen added. Whether that part of the pressure due to the carbon dioxide (the partial pressure of that substance) is independent of the total pressure is purely an experimental question which the phase rule cannot decide. We commonly assume that it is, but an analogy with the effect of the pressures of inert gases on the vapor pressures of liquids shows very probably that it is not. However, such effects in the case of liquids are negligible except in the case of high pressures. A pressure of an inert gas amounting to three hundred atmospheres raises the vapor pressure of water by 20 per cent. The above case indicates that it is by far the safest procedure to include all the variables that are present in a given system and only subsequently exclude those which may be shown by experiment to have a negligible effect on the properties of the system. Washburn (*2*) has clearly pointed out the danger of neglecting the effects of atmospheric pressure on physical measurements and shows something of the magnitude of the effects and the manner of correcting for them.

The problem of a salt in equilibrium with one of its hydrates is one of considerable interest. The molecular species in such a system are evidently salt, hydrate, and water and there are two solid and one gaseous phases. There is a chemical equation for the formation of the hydrate from the anhydrous salt and water. Case 11 shows one degree of freedom, that is, for a definite temperature the pressure of water vapor is constant above an anhydrous salt and a hydrate, or above two hydrates of the same salt. If only the hydrate and water are present the system belongs under Case 5 and has two degrees of freedom. It is not correct to speak of the vapor pressure of a salt hydrate without stating with what other solid phase (salt or other hydrate) the system is in equilibrium.

In the presence of air, which may for simplicity's sake be considered as containing only nitrogen, the number of constituents is increased by one and Case 12 shows that the system has two degrees of freedom. As in the case of the calcium carbonate–calcium oxide equilibrium, air or nitrogen has but slight effect on the partial pressures of the gaseous constituent unless present at very high pressures. Therefore, the partial pressure of the water from a non-volatile salt hydrate pair is usually considered to be the same as the total pressure of the same pair without the presence of the air.

In the case of a salt which dissociates in water solution to form two ions, the constituents are evidently the undissociated salt, water, and the two ions. If they are present only in the liquid phase Case 13 shows the system to have four degrees of freedom. However, since the concentrations of the two ions in the solution must be equivalent in order to keep the solution as a whole unchanged, the number of degrees of freedom is one less. If the temperature and the pressure are fixed the properties of the system are completely determined on fixing one concentration term. Since the

concentrations of the ions and undissociated salt cannot be accurately determined it is usual to fix the total salt concentration. The concentration is the sum of the concentrations of the undissociated salt and the ions and the latter are determined by the total concentration and mass law equilibrium for the dissociation of the salt. If a compound dissociates in such a way as to give three different ions it is possible to indicate the intermediate steps in the process. For example, in the case of sulfuric acid

$$H_2SO_4 \rightleftharpoons HSO_4^- + H^+$$
$$HSO_4^- \rightleftharpoons SO_4^{--} + H^+.$$

The number of constituents is increased by one over the previous example, which for a one-phase system increases the variables by one but at the same time the number of chemical equations is increased by one and the number of degrees of freedom is the same (Case 14). In general, therefore, for electrolytes in solution it is not necessary to consider the ions as separate molecular species. On the contrary, for gaseous dissociation, as has been shown for ammonium chloride, it is often necessary to consider the dissociation products as distinct molecular species. The reason for the difference is that it is possible to add one of the dissociation products without adding the other. In the case of electrolytic dissociation this is impossible because the solution as a whole must remain neutral. In order to increase one ionic concentration without increasing the other correspondingly, it is necessary to add a salt with a common ion, as adding sodium acetate to an acetic acid solution. Case 15 shows five degrees of freedom for such a system in one case and this must be diminished by one on account of the equivalence of the positive and negative ions in the solution. Its properties are completely fixed by determining the temperature, the pressure, and the total concentrations of the salt and the acid.

The usual statement of the phase rule uses the term component instead of molecular species or constituents, the number of components in the system being defined as the smallest number of molecular species whose concentrations will determine completely the composition of the system. An alternative method which amounts to the same thing is to reckon the total number of molecular species in the system and subtract from that number the number of equations connecting the concentration of these constituents. Such equations are usually equilibrium equations but there may be others also as, for example, the equality of the equivalent concentrations of ions from a simple binary electrolyte. In the system calcium carbonate–calcium oxide–carbon dioxide, three molecular species and one chemical equation, the number of components is two. With a solution of common salt in water there are four constituents and a mass law equation connecting the concentrations of the ions and undissociated salt as well as an equality in the equivalent concentrations of the sodium and chloride ions, indicating

a two-component system. Similarly, for acetic acid–sodium acetate–water, a system containing six molecular species, there are two mass law expressions and the sum of the equivalent concentrations of the sodium and hydrogen ions must equal the equivalent concentration of the acetate ion indicating three components. This, of course, neglects the concentration of the ions derived from water. Considering them would introduce another constituent, the hydroxyl ion, but at the same time there would be the dissociation equilibrium for water and the number of components would be the same as in the previous case.

The examples given should make the general method of treatment of the phase rule clear and the student should be given other and perhaps more complicated problems to solve until he understands thoroughly the line of reasoning on which the rule is based and sees its connection with the various simple types of equilibrium expressions. He may then be allowed to use the more usual form of the rule. A simple and non-rigorous deduction of this form of the rule follows.

Let the number of phases be P, the number of molecular species be N, and the number of degrees of freedom be F. The total number of variables equals the concentration terms for each molecular species in each phase plus the temperature and pressure. As has been previously shown in Cases 7 and 8, the absence of a molecular species from any particular phase has no effect on the final result. We may, therefore, consider that each constituent is present in each phase and that the total number of concentration variables is equal to the number of molecular species times the number of phases. The total number of variables is, therefore, $NP + 2$. The number of equations of state is equal to the number of phases present, namely P. The number of independent distribution equations is equal to the number of molecular species times one less than the number of phases as has been previously shown. The number of chemical equations plus the number of independent equations connecting the equivalent concentrations of the constituents in the same phase is E. Examples of the latter type of equation have been shown in the case of electrolytic dissociation and for the dissociation of ammonium chloride when the only ammonia and hydrochloric acid were produced from the dissociation. The total number of equations is, therefore, $P + N(P - 1) + E$. The number of degrees of freedom is equal to the total number of variables minus the number of independent equations connecting these variables

$$F = NP + 2 - P - NP + N - E = N - E - P + 2.$$

The number of components for the system (C) has previously been defined as the total number of molecular species less the number of equations connecting their concentrations: $C = N - E$. The rule then reduces to the usual form $F = C - P + 2$.

An examination of the conditions under which the phase rule cannot be expected to hold, at least in its usual form, will not only tend to eliminate errors in its application but also throw light upon the fundamental assumptions upon which the rule is based. The exceptions to the phase rule belong to two types. The first includes those cases in which equilibrium has not been reached and the system is likely to change its condition with time. In the other type, all the variables which have an effect on the physical properties of the system have not been taken into account in the derivation of the rule.

In the treatment of the first type of exception it will be assumed, as has previously been done, that the only variables which determine the properties of the system are the temperature, the pressure, and the concentrations of each substance in each phase.

In a system of limited extent and free from outside influences, temperature equilibrium will soon be reached and all parts of the system will be at the same temperature as postulated in the derivation of the phase rule. By thermally insulating a portion of the system from the rest, as by a Dewar flask, the attainment of such equilibrium can be somewhat delayed, but usually not for long except in the special case in which the attainment of some other equilibrium produces or absorbs heat. An example of the latter process is the evaporation of liquid air contained in a Dewar bulb. When part of the system is continuously heated or cooled from outside, it is possible to secure a uniform temperature gradient over long periods of time as in experiments on the Soret effect. It is obvious that the phase rule in its usual form does not apply in the above cases.

Three possible cases in which the pressure throughout the system is not uniform will be mentioned. The first of these is the variation in pressure when the system is subject to the action of gravitational or centrifugal forces. This case properly belongs to the second type of variation since the system may be in a condition of equilibrium. Another case is that in which part of the system is separated from another part by a membrane which will allow some of the constituents to pass through but not others. Suppose such a system consisting of a water solution of cane sugar is in osmotic equilibrium with a more dilute solution of sugar or with pure water. Let the osmotic pressure be π. The concentrated solution inside the cell is evidently a separate phase from the water or more dilute solution outside. Moreover, the pressure on the inside phase is the sum of the pressure on the outside phase and the osmotic pressure. The system shows two molecular species in two phases. The variables are temperature, two pressures, and four concentrations, a total of seven. There are two equations of state but only a single distribution equation since the cane sugar cannot pass through the membrane. There is, however, an additional equation connecting the concentration of the cane sugar with the osmotic

pressure. In case there is cane sugar outside, the concentration term represents the excess concentration inside. The simplest form of this equation is the van't Hoff expression for osmotic pressure: $\pi = \frac{n}{v} RT$ or $\pi = CRT$. This equation is in the form of an equation of state, that is, it expresses the pressure volume product as a function of the temperature for a phase of fixed composition. We have, however, considered the total pressure on the phase inside the osmotic cell as the sum of the osmotic pressure and the pressure on the outside phase. Therefore the osmotic pressure equation is not independent of the usual form for the equation of state for the inside phase. This calculation (Case 16) shows the total number of variables to be seven with three equations connecting them, giving four degrees of freedom, or one more than the same system without the membrane as shown in Case 4. This means that if the temperature and pressure on the outside phase have a definite value, it is necessary to fix both the inside and outside concentrations of cane sugar in order to determine the osmotic pressure and hence the total pressure on the inside phase. Only when we have no cane sugar outside does the osmotic pressure depend on a single concentration of cane sugar.

Another important case of non-uniform pressure is met with in the case of a solid phase subjected to shearing stresses. It is evident that the phase rule does not apply, since the pressure on the system is not uniform. Even when the shearing stresses are removed, the solid does not always resume its former condition. A cold-worked metal has very different properties from the annealed material even though the composition, the temperature, and the pressure of the two samples are precisely alike. That the two specimens are not in equilibrium may be shown by making them electrodes in a solution of the salt of the metal as an electrolyte. The strained metal will be charged negatively, showing its tendency to go into solution and change to the more stable form. This cause of error in the application of the phase rule is particularly likely to be important in the study of metallography. In the above-mentioned case the differences in the two samples results from a merely physical change in the strained metal. In other cases the change may be a chemical one or the two forms of change may both take place. For example, in the annealing of hardened steel, the decomposition of the carbide of iron (Fe_3C) takes place as well as pronounced changes in the physical condition of the resultant products, and such effects produce very great variations in the properties of the resultant metal. It is evident that great care must be used in the application of the phase rule to systems involving solids which have been subject to shearing stresses of considerable magnitude or to large and sudden changes in temperature.

In the case of a single liquid or gaseous phase, physical equilibrium is generally easily obtained, especially on agitation, but this is not necessarily

the case for chemical equilibrium. For example, oxygen and hydrogen may be left in contact with one another indefinitely without chemical action, provided no catalyst is present. In such case the chemical reaction may be disregarded entirely and the phase rule applied. The main difficulty comes in the case of a reaction with a slow but finite velocity and as a consequence the properties of the system change with the time.

In a system consisting of liquid and gaseous phases only, the various possible distribution equilibria are doubtless soon attained if the system is properly agitated, but this is not the case in systems involving solids. Diffusion in solids is a relatively slow process except at temperatures very near the melting point of the solid and the usual way of attainment of the distribution equilibrium in solids is by this diffusion process. It is true that the formation of solid solutions is of relatively rare occurrence and the crystalline solid phase does not often contain appreciable concentrations of more than one substance. In the case of solid solution formation the attainment of distribution equilibrium is of very great importance. It is ordinarily supposed that in the case of such a solution formed from a melt that the solid phase is at all times in equilibrium with the melt during the cooling process and the solidus and liquidus curves are plotted accordingly. It is very doubtful if such equilibria are always attained and the chances are still less when it comes to the distribution of a substance between two solid phases. The only criterion for equilibrium attainment is to cut down the cooling rates until no further effect is observed on the composition of the phases or on the thermal diagrams. If considerably slower cooling has no effect, equilibrium has doubtless been attained in the more rapid process.

The second general type of exceptions to the phase rule results from the fact that the pressure, temperature, and concentrations of each molecular species in each phase, in certain cases do not completely determine the value of all of the properties of the system. This is the case when the surface of contact between phases is very large or when the system is subjected to gravitational, centrifugal, electrostatic, or electromagnetic forces.

The effect of the contact surface between two phases upon the properties of a system is best studied in cases of adsorption and colloidal solutions, where often such surfaces are extremely large. It is very evident from the results of adsorption experiments that the extent of surface of the adsorbent has a very great influence on the concentration of the adsorbed substance in the phase from which the adsorption takes place. In the derivation of the phase rule it has been assumed that the distribution of a substance between two phases is influenced only by the temperature, the pressure, the volumes of the phases, and their composition. The phase rule cannot, therefore, be applied when the surface of contact is very large. In ordinary cases, in which a phase is not divided beyond macroscopic size, experiment

shows the surface concentrations to have little effect on the properties of the system and the rule is applicable.

It is probable that in very many cases of extensive contact surface between phases the system is not in true equilibrium and, therefore, may be considered to belong to the first type of exception. This is very evidently the case for emulsions in which the interfacial surface tension has a finite value. Since the surface energy always tends to reach a minimum value, only those emulsions with extremely low interfacial surface tensions would show any considerable stability. The instability of the lyophobic type of colloidal suspensions is clearly shown by the fact that they are irreversibly coagulated by electrolytes, especially of the higher valence types, in amounts far too small to have an appreciable influence on the free energy of the system.

On the contrary, certain lyophilic colloidal systems show a considerable degree of reversibility. Colloidal sulfur produced by oxidation methods may be precipitated by electrolytes and peptized by washing them out. Gelatin may be dried and again put into solution with water. Some inorganic colloids such as silica gel show the same phenomena. In most cases the properties of such systems are to a large extent dependent on their mode of formation and previous history. It is difficult to determine, in cases like the above, whether the systems are in true equilibrium or not, but it is evident that the phase rule in its ordinary form does not apply. For a discussion of modifications of the rule to apply to colloidal systems the reader is referred to papers by Tolman (*3*) and Rice (*4*). The above authors also discuss the question of equilibrium in such systems.

Another type of independent variable which may be considered includes gravitational and centrifugal fields. Such fields, of course, have vectorial properties, that is, their effects change with the orientation of the field with reference to that of the system and in addition particularly in the case of centrifugal fields they are rarely uniform for a system of any considerable size. As a consequence their application in the case of the phase rule usually involves the consideration of more than one additional variable. For example, the effect of gravity on the earth's atmosphere may be considered to depend on the gravity constant at sea level and the height above sea level of the part of the system under consideration, in other words, on the dimensions of the system in a direction perpendicular to the earth's surface. It has been specified in the deduction of the phase rule that the properties considered are intensive and are therefore independent of the size and shape of the system. It is evident that the introduction of intensive and vectorial properties would make the problem very complicated.

The same considerations apply also to a system under the influence of electrostatic or electromagnetic fields. Such fields are always vectorial and

are rarely uniform over a system of any considerable size. The phase rule in any simple form cannot, therefore, apply.

It is interesting to summarize briefly the assumptions upon which the phase rule is based and the part played by thermodynamics in the deduction of the rule from the assumptions. It is assumed that the properties of the system treated are entirely dependent on the concentration of each molecular species in each phase, the temperature, and the pressure, and are independent of the size and shape of the system, or of the time both past and future. Such an assumption excludes extensive properties, systems which are not in equilibrium, or subject to gravitational, centrifugal, electrostatic, and electro-magnetic fields as well as colloidal systems. That the concentrations of the various molecular species in the same phase are related by a law of mass action, expression for each chemical reaction may be demonstrated by the laws of thermodynamics. Moreover, thermodynamics shows that the concentration of each substance in any phase is related to its concentration in each of the other phases by a distribution equation.

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THE TEACHING OF FIRST-YEAR ORGANIC CHEMISTRY*

JOHN R. SAMPEY, HOWARD COLLEGE, BIRMINGHAM, ALABAMA

For several years the author has sought to enlist the interest of young future blast-furnace superintendents and cast-iron pipe foremen in the idiosyncrasies of triphenylmethane dyes and related phenomena of organic chemistry. After prolonged exposure to such an experience one is apt to ponder the words of an old Roman teacher in which he says, "The Lord knoweth the thoughts of the wise, that they are vain."

Fortunately, not every instructor of organic chemistry has to pass through such an experience. Another illustration may serve better to lead him to question the wisdom of his methods. At one of the semi-annual meetings of our Society a few years ago one of the leading physical chemists in America stated to the Division of Organic Chemistry that he felt real trepidation in appearing before such a body, because as a student he had been unable to pass the first-year course in organic chemistry.

The teacher of a course in first-year organic chemistry, who gives serious thought to the pedagogy as well as the subject matter of his work, recognizes that he is faced with at least three major problems. First, how can he bridge the gap between inorganic and organic chemistry? Second, how can he help the student to classify and correlate the large number of individual reactions? And third, how can he give the student a rational interpretation of the mechanism of organic reactions?

The reactions of organic chemistry are so different from those of inorganic and analytical with which the student has become familiar that he is soon confused. There is so little in his previous training that he can bring over into the new field. The theory of ionization, the periodic table, and the electromotive series afford him little guidance. What is more disconcerting, he early concludes that he is dealing with a new type of valence, and that his mastery of how to balance oxidation and reduction reactions by the loss and gain of electrons will profit him little in dealing with "molecular reactions." Finally, the phenomenon of structural isomerism deals a heavy blow to his faith in the interpretation of reactions by means of the Bohr model of the atom.

Modern textbooks are coping with the problem of bridging the gap between inorganic and organic chemistry. Progress has been made in reconciling the two supposed "types" of valence by emphasizing Lewis' ideas of the nature of a chemical bond in the explanation of the difference between polar and non-polar compounds. The cubic atom simplifies the explanation of structural isomers, but if the student insists on holding to the Bohr model, his previous difficulties may be avoided by the assumption that the planes of the electron orbits occupy fixed positions about the nucleus of the atom. There are many other ways in which the princi-

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ples of physical and inorganic chemistry may be applied to organic reactions; we hasten to the second major problem of the first-year course.

The hardest task the student faces is the correlation of the many classes of substances studied in the first-year course in organic chemistry. In order that he may keep in mind even the most characteristic reactions of the hydrocarbons, alkyl halides, alcohols, aldehydes, ketones, ethers, acids, esters, anhydrides, amines, cyanides, and nitriles, to mention a few of the more important types of aliphatic compounds only, the student must devote an appreciable fraction of his study period every day to review. The instructor who seeks to encourage the student in this review, by calling upon him to list the methods of preparation and the properties of the compounds studied previously, soon finds the recitation period growing monotonous. In order to stimulate the interest of the class in this necessary part of the daily assignment, the author has resorted to several exercises. He claims little originality for these suggestions, but it has been his experience that they contribute a freshness throughout the year to what otherwise would prove a dull drill.

The exercises apply to sections of not more than twenty each. This limit is placed so that the whole class may work at the blackboard simultaneously. While some of the exercises may be performed more easily through oral recitations, the written work demands a higher degree of accuracy. We may well add here that in taking up a new assignment the class is drilled at the board on the new reactions. An effort is made to keep the class at the board at least two-thirds of each class period.

The first exercise to stimulate the correlation of the material covered is the synthesis of some compound from a given starting material. This synthesis will usually involve several steps, and not infrequently it will call for the lengthening or shortening of a carbon chain. The synthesis which requires the fewest steps and is complicated by the fewest side reactions is awarded the highest grade. To make the exercise more instructive, the student is encouraged to specify as often as possible the experimental conditions for each step.

There is one evil to be guarded against in this exercise. The student has a tendency to fall into the habit of writing down equations which he thinks might take place. The requirement to state the exact experimental conditions for each reaction helps to cut down this "blackboard" chemistry. An even better plan, especially in the early stages of instruction, is to have the student place opposite each equation the number of the page in the textbook on which the reaction is found. The student, of course, is given access to his book during the working out of this modification of the exercise.

The second exercise is designed to emphasize the difference in the properties of the several classes of compounds. The student is given

the names of a mixture of two or more compounds that are placed in an imaginary beaker, and he is requested to separate the same by some method other than fractional distillation or crystallization. The most convenient method of accomplishing this result is to add some reagent that will react with one of the compounds present and not the others. After such a reaction has taken place the student is at liberty to separate the products by distillation, extraction, or crystallization. If the student adds a reagent that reacts with more than one of the original substances, he must know how to separate the products of these reactions. This exercise teaches physical as well as chemical properties. It may be made more comprehensive by requesting the student to restore the products of the separation to the original substances.

The third and final exercise to be considered gives the student an introduction into the methods employed in a course in the qualitative separation of organic compounds. An imaginary compound of unknown constitution is handed the student, and he is requested to identify the same by a series of reactions that are diagnostic of the particular type of compound in question. In his efforts to determine the nature of the unknown he is permitted to ask the instructor only those questions that he could receive an answer to by actual laboratory experimentation. When a student asks if such and such a reagent reacts with the unknown, the favorite reply is, "How would you tell that a reaction did take place?" With a little practice the student learns to ask the results of specific reactions which will throw the unknown into certain large classes of compounds. In his further efforts to narrow the search down to the individual substance, he will often ask questions that will tax the instructor's knowledge of organic reactions. The story is told that on an oral examination of a graduate student when this little game was being played, with glucose as the unknown substance, after the candidate had determined that the compound was a carbohydrate, he began propounding such specific questions for the identification of the particular sugar that the instructor had to call for assistance from the other members of the examining committee. This exercise on the identification of organic substances may be made as simple or as complex as desired, and there is no reason why a class in first-year organic chemistry should not be able to derive, with a minimum expenditure of time, some of the benefits of a laboratory course in the identification of organic compounds. None of these exercises, however, is recommended for summer school courses that attempt to complete a year's work in organic chemistry in one semester of six weeks.

We have yet to discuss the third major problem, that of giving the student an interpretation of the mechanism of organic reactions. The history of organic chemistry is so replete with the names of men who have made contributions in this field that a brief historical treatment of the

subject will prove helpful. For example, to explain unsaturated phenomena we can refer to the work of von Baeyer, Victor Meyer, and Thiele; in the field of stereoisomerism we can point to Pasteur, van't Hoff, and Le Bel; and for the elucidation of the structure of benzene we have Kekulé and Holleman. More recently there has been developed, largely through the researches of W. A. Noyes, Stieglitz, Fry, and Kharasch, an electronic theory of valence to explain such unrelated properties as the strength of acids, the addition reactions of unsaturated compounds, molecular rearrangements, and substitution reactions in the benzene ring. Some teachers have questioned the wisdom of introducing the first-year student to electronic interpretations, but modern texts are devoting more and more attention to this subject, and it has been the experience of the author that when the subject is treated in the light of G. N. Lewis' ideas of polar and non-polar bonds the student receives a clearer insight into the mechanism of organic reactions than he can derive from any other source.

In conclusion we shall mention two other ways of helping the student understand organic reactions. One of these is through the study of residual or secondary valence forces. In the slow molecular reactions of organic chemistry intermediate compound formation plays a leading rôle. Werner's ideas of residual valence are being applied increasingly to the elucidation of organic reactions, and evidence is being disclosed for the existence of intermediate compounds in many types of reactions.

As a concluding suggestion, the student may be pointed to the growing literature on the applications of physical chemical methods to the study of organic reactions. These methods are being applied from many angles, but all the research has as its ultimate objectives the determination of the distribution of valence forces within an organic molecule, and the method by which these forces are brought into play during a chemical reaction. This investigation into the quantitative side of organic reactions has already shed much light upon the mechanism of the reactions, and it can be used to advantage in increasing the respect of blast-furnace superintendents, cast-iron pipe foremen, and physical chemists for the science of organic chemistry.

Light Limits Visibility of Atom. Man will never be able to look distinctly at an atom, according to Prof. G. P. Thomson, English physicist. Even if apparatus is developed which might enable man to enlarge the vision of an atom to a point where his eye might see it, he would perceive only a blur, for he would be looking at an atom in motion. The electrons, of which we conceive atoms to be composed, would be knocked about, largely by light rays. A ray of light is thought of as a delicate thing, but when light reaches so small a thing as an atom it no longer is delicate. It gives the atom a severe poke. Thus light itself becomes a barrier which limits vision.—*Chi Beta Phi Record*

TEACHING THE SOLUBILITY PRODUCT PRINCIPLE

F. S. MORTIMER, ILLINOIS WESLEYAN UNIVERSITY, BLOOMINGTON, ILLINOIS

In general, it may be said that the preparatory training of the students entering courses in college chemistry varies over a wide range. Many have had little or no training in abstract thinking in terms of mathematical formulas even of the simplest type. The presentation of the solubility product principle and its application to the solution of problems in analysis to such students is sometimes a difficult task. We first develop the principle and then apply it in various ways. Among the applications which we always use is the fractional precipitation of mixed solutions of iodide, bromide, and chloride by the slow addition of silver nitrate. Those students who are mathematically inclined easily follow the reasoning but there is always a larger number who need more help. For their benefit we have found it helpful to make use of the old lever principle in the following manner.

Balancing a meter stick at the mid-point above the lecture table, we let one end represent the cation and the other the anion. The heights above the table represent the concentration of the ions. For convenience we may take the initial concentrations of $(\bar{I})$, $(\bar{Br})$, and $(\bar{Cl})$ all equal to 0.1 mol per liter. Now even the poorest student can see that as the concentration of the cation increases, that of the anion decreases. And to show that a larger concentration of silver ion is required to initiate the precipitation of AgBr or AgCl all that is necessary is to raise the fulcrum of the lever to greater elevations for these substances. The student, of course, must clearly understand that the lever principle applies only to the saturated solution and that the concentrations used are the amounts actually remaining in solution and are not necessarily equal to the total amounts added. By such a device even the backward student may readily see why the iodide will be almost completely precipitated before the bromide begins and the bromide, in turn, before the chloride begins.

The above is about as far as some of the students will be able to go but many others should be able to follow the simple mathematical treatment which follows. From the equation $(\overset{+}{Ag})\cdot(\bar{I}) = K_{sp}$, it is evident that doubling the concentration of the cation in the solution causes the concentration of the anion to be decreased to one-half its former value. A little reflection will show, however, that this cannot be shown by the lever when the elevation represents simple concentrations. For if one end is elevated to twice its height the other end is lowered to the table, or to zero concentration. If, however, we take the height to represent the logarithm of the concentration of the anions and cations in the saturated solution then the lever may be used because, in multiplying or dividing by a given number using logs, we simply add or subtract the log of the number which is here represented by a distance or elevation.

We have found that many students in beginning chemistry have not studied logarithms. For these the simple application of the lever principle is helpful to a qualitative understanding of the equilibrium relations. Generally speaking, those who have studied logarithms need some additional instruction when it comes to using very large or very small numbers. The following table illustrates the point.

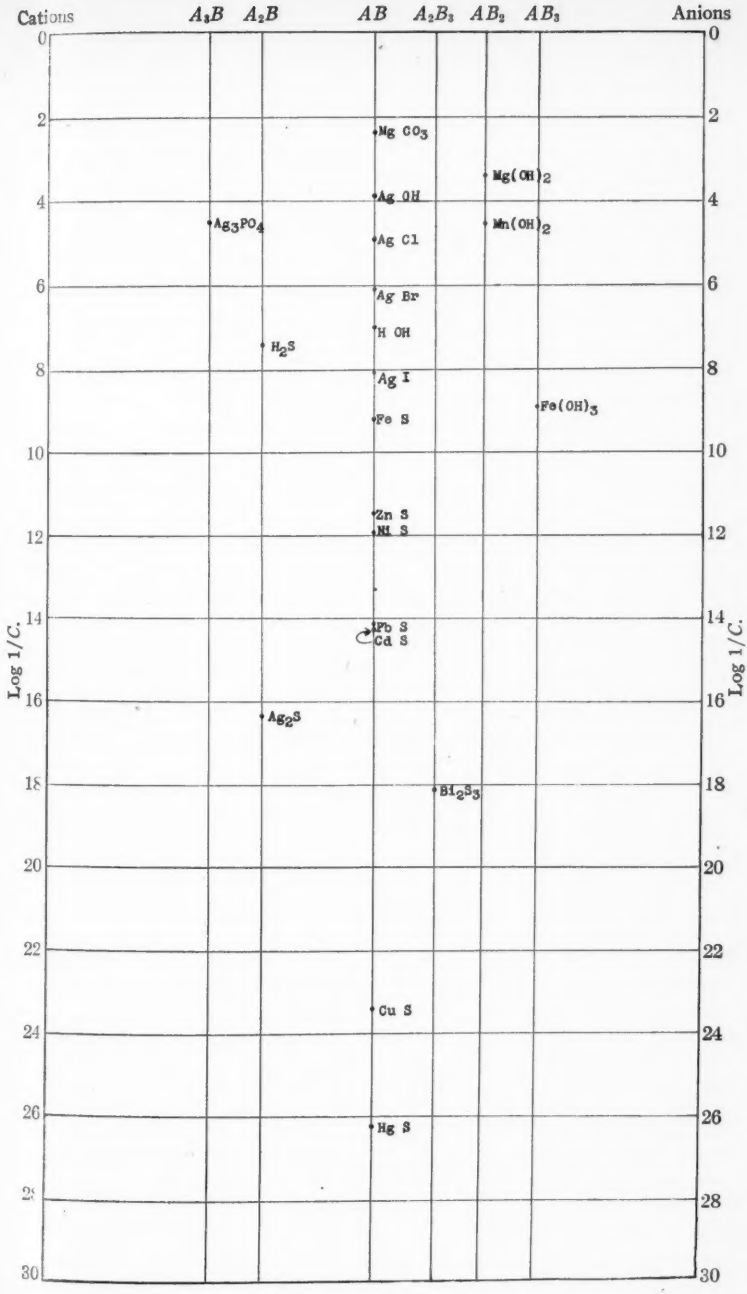
TABLE I

Number	*Exponential number*	*Logarithm (as taught)*	*Logarithm (preferred)*	*Log expressed as a number*
2500	2.5×10^{3}	3.398	3.398	3.398
2.5	2.5×10^{0}	0.398	0.398	0.398
0.25	2.5×10^{-1}	9.398–10	$\bar{1}$.398	−0.602
0.0025	2.5×10^{-3}	7.398–10	$\bar{3}$.398	−2.602
$0.0_{7}25$	2.5×10^{-8}	2.398–10	$\bar{8}$.398	−7.602

In algebra the student is generally taught to use logs as shown in column (3). We prefer the method shown in column (4). In general, we write all numbers with the decimal after the first significant figure. The exponent of 10 then becomes the characteristic of the logarithm. The mantissa, of course, is positive and for numbers less than one the logarithm is a mixed number. It may be made a simple negative number as shown in column (5). If now the negative sign is removed we have what amounts to the logarithm of the reciprocal of the number or log $1/N$. For these calculations a three-place log table is sufficiently accurate, in fact, a slide rule is the ideal instrument for making the calculations and reading off the logs. This then becomes the method of expressing the data. Instead of using molar concentrations directly we use log $1/C$. This method is, of course, already familiar to those who have studied the pH values of aqueous solutions.

To make use of the lever principle with any degree of precision it is now necessary to construct a nomographic chart on coördinate paper. We have used a sheet 10 × 15 inches ruled twenty lines to the inch. We also have a much larger chart for classroom use. We have reproduced a small portion of the data in the accompanying figure but this chart is not graduated finely enough to warrant its use except to illustrate the method. In a few minutes any one can construct a good nomogram and we encourage each of our students who use logarithms to do so.* We have placed the cations at the left and the anions at the right. Then, for each sparingly soluble substance, there is a position on the nomogram which is the intersection of all straight lines joining the points representing the equilibrium concentrations of the anions and cations composing the substance.

* The data we have used were taken from the summary in "Inorganic Quantitative Analysis," by Fales, The Century Co., New York City, 1925, 493 pp.



NOMOGRAPHIC CHART

It will be observed that all substances of the type AB have points which lie on the mid-line of the chart. The elevation of the point for a given substance of this type will be equal to the logarithm of the reciprocal of the mol solubility or log $1/C$. For substances of the type A_2B and AB_2 the intersections lie on lines that are one-third and two-thirds, respectively, of the distance between the cation and anion sides and at an elevation which represents the cube root of the solubility product constant or log $1/(K_{sp})^{1/3}$. Likewise for substances of the types A_3B and AB_3 the intersections lie on lines that are $^1/_4$ and $^3/_4$, respectively, of the distance from the cation to the anion side and at an elevation which represents the fourth root of the solubility product constant or log $1/(K_{sp})^{1/4}$. The position of still other types will be evident from the above statements.

It should be noted that except for the type AB the location of the point in the chart is not exactly at the elevation which represents the mol solubility. An illustration will make this clear. The salt Ag_3PO_4 dissolves to the extent of 1.6×10^{-5} m. per l. Assuming complete ionization the solubility product constant is calculated in the usual manner,

$$K_{sp} = (\overset{+}{Ag})^3 (\overset{---}{PO_4}) = (3 \times 1.6 \times 10^{-5})^3 (1.6 \times 10^{-5}) = 178. \times 10^{-20}.$$

The position on the nomographic chart is log $1/(178. \times 10^{-20})^{1/4}$ or 4.44. Now the log of $1/1.6 \times 10^{-5}$ is 4.8. Thus it is evident that the position in the chart for all substances except the type AB is not that of log $1/C$.

Because of their importance in analysis we have placed on our chart two other substances, *viz.*, water at 7.0 and H_2S at 7.65. This last is based on the assumption that a saturated solution of H_2S is 0.1 M and that the ionization constant is 1.1×10^{-22}. Hence $(\overset{+}{H})^2 (\overset{--}{S}) = 1.1 \times 10^{-23}$. We have found that this approach helps the student to an understanding of the meaning of pH.

The chart may be used for numerous calculations, some of which may be illustrated. In the problems which follow we have used a small desk chart drawn on coördinate paper 10×15 inches and ruled twenty lines to the inch. Let us suppose that we have a solution which is 0.1 M with respect to $(\bar{Cl})$ and ask the question, What concentration of $(\bar{I})$ may remain in solution when the AgCl just begins to precipitate?

Solution: Place a straight edge across the chart in such a way that it cuts through the point 1.0 on the anion side corresponding to 0.1 mol of $\bar{Cl}$, and the point for AgCl and find where it crosses the cation side. This will be found to be 8.75. Then, holding this point, swing the ruler down so that it passes through the point for AgI and find that it crosses the anion side at 7.27. Hence log $(\bar{I}) = \overline{8.73}$ and $(\bar{I}) = 5.4 \times 10^{-8}$.

Another instructive problem might be to find what concentration of Zn^{++}, Ni^{++}, Pb^{++}, and Cd^{++} ions may remain in solution when a solution containing 0.25 mole of $(H)^{+}$ is saturated with H_2S. *Solution:* Place a ruler through the point 0.6 on the cation side corresponding to log 1/0.25 and the point for H_2S and find the point 21.7 on the anion side. This represents the concentration of the sulfide ion. Holding the ruler on this point, pass it successively through the points for ZnS, NiS, PbS, and CdS and read the values 1.1, 2.1, 6.55, and 6.75 on the cation side. These correspond to 8.0×10^{-2}, 80×10^{-3}, 2.8×10^{-7}, and 1.8×10^{-7}, respectively, as the concentrations of the cations. This problem demonstrates very conclusively the importance, not only of adjusting the concentration of the acid in separating Groups II and III in the qualitative procedure, but also the necessity for proper dilution of the solution before addition of the H_2S.

We have found that aside from being a rapid method for solving problems, this application of the "lever principle" helps even the most backward student in applying the solubility product concept even though he does not understand the logarithms. For those who can handle the logarithms it is most valuable when each is asked to make up his own chart from solubility data that he gathers in the library.

AN ASBESTOS CRUCIBLE

PAUL T. STONE, WOMEN'S COLLEGE OF ALABAMA, MONTGOMERY, ALABAMA

This so-called asbestos crucible is a device intended for use in the general chemistry laboratory. It was designed for combustions which are of such intensity as to render a porcelain vessel unfit for further use. Economy is the only advantage claimed for it. It is satisfactory only in cases where contamination of the product by adhering asbestos lint is of little consequence. It has been used in the author's laboratory for the combustion of sucrose mixed with a chlorate, and for other similar reactions.

It is prepared by the student from a circular disk of thin asbestos paper by exactly the same technic used in preparing a paper filter for a conical funnel. After folding and opening, the cone is supported in a small iron ring or in a clay triangle. If the crucible shows any tendency to open up, this is readily corrected by the use of a pin or small paper clip. It is heated from below by directing the flame against the thin side.

Obviously, the crucible is intended to serve for one combustion only. A disk of 11 centimeters diameter supported, when folded, in a ring of 5 centimeters inside diameter has been found to be of convenient size.

THE RECORDING OF VALENCE AND IONS IN TERMS OF ELECTRONS

C. Pauline Burt, Smith College, Northampton, Massachusetts

A student who is undertaking the study of chemistry for the first time is apt to have difficulty in interpreting ion charges in terms of electrons. The reason for this confusion of mind is easy to understand for the student usually learns the terms, *valence* and *charges*, and practices with them long before he realizes their significance electronically. Representing ions as he does, it is quite logical for him to think of them only as carriers of positive and negative charges, and with this firmly fixed in his mind it is somewhat of a task, and a confusing one, to translate charges into electrons.

Since the electron theory has already been introduced into elementary texts, it would seem logical to present the idea of chemical combination from the very beginning in terms of electrons. This idea has been worked out in several elementary chemical texts published within the past few years and has been presented in such an excellent way that within the first few weeks a beginning chemistry student is able to understand the underlying principle of electronic changes in chemical reactions. The significance of combining power as a tendency for atoms to gain or lose (or share) electrons is at once apparent to the student. However, the authors then proceed to translate electrons back into the accepted concept of valence, using the same old method of recording ions and thereby compelling students to continue the use of a transference method, but in the reverse order. This method, though logical at the outset, finally offers nearly as many difficulties as the older method of procedure.

If, however, a method of recording combining power in terms of electrons were introduced at the very beginning of the course no translation of positive and negative charges would have to be made, for all chemical representations could be kept in those terms. The material could be presented as follows. The fundamental concepts of the structure of the atom could first be presented, followed by the teaching of Faraday's law, and the student would then have in hand the essentials for the understanding of chemical combination. Application of Faraday's law would indicate the valence, that is, the number of electrons the atom is capable of gaining or losing, while the changes at the anode and cathode would show whether the atom had a tendency to be an electron gainer or loser. Electron gainers would therefore tend to become hyper-electronic and be represented as $\overset{+1\epsilon}{Cl}$, $\overset{+2\epsilon}{SO_4}$, $\overset{+3\epsilon}{PO_4}$, instead of $\overset{-1}{Cl}$, $\overset{-2}{SO_4}$, $\overset{-3}{PO_4}$. Electron losers would tend to become hypo-electronic, represented as $\overset{-1\epsilon}{Ag}$, $\overset{-2\epsilon}{Pb}$, $\overset{-3\epsilon}{Al}$, instead of $\overset{+1}{Ag}$, $\overset{+2}{Pb}$, $\overset{+3}{Al}$. Thus the electronic condition of an element when it is in combination would be the valence. Strictly speaking, even in our present

way of indicating valence, the valence should not be written above a symbol standing alone (as above) for, if the element is uncombined, the valence is zero. The same applies to hypo- and hyper-electronic atoms. However, in order that the mechanics of making formulas be served, this inaccuracy is often permitted, and this could be continued in using the new method. At least this different way of expressing valence would not make the deducing of formulas any more difficult, and besides being more logical, it would simplify greatly the interpretation of ionic reactions.

The writing of ionic dissociation equations would be changed only in that the ions would be expressed as being hypo- or hyper-electronic, instead of carrying positive or negative charges.

Old way: $HCl \longrightarrow \overset{+}{H} + \overset{-}{Cl}$

New way: $HCl \longrightarrow \overset{-1\epsilon}{H} + \overset{+1\epsilon}{Cl}$

Here, hydrogen in dissociating is shown directly as losing an electron to chlorine.

The sum total of electronic change in the displacement action of zinc and copper would be much simpler to discern.

Old way: $\overset{0}{Zn} + \overset{+2}{Cu} + \overset{-2}{SO_4} \longrightarrow \overset{+2}{Zn} + \overset{0}{Cu} + \overset{-2}{SO_4}$

New way: $\overset{0}{Zn} + \overset{-2\epsilon}{Cu} + \overset{+2\epsilon}{SO_4} \longrightarrow \overset{-2\epsilon}{Zn} + \overset{0}{Cu} + \overset{+2\epsilon}{SO_4}$

The change could be read directly from the second equation, that is, it would involve merely a transference of two electrons from zinc to copper.

In the mechanism of electrolysis of a cupric chloride solution, the dissociation equation would be written thus:

$$CuCl_2 \longrightarrow \overset{-2\epsilon}{Cu} + \overset{+1\epsilon}{2Cl}$$

This would at once indicate that if chlorine and copper are to become electrically neutral as the experiment shows, chlorine being hyper-electronic must lose its electrons while copper, being hypo-electronic, would gain them. It is thus easy for the student to reason that chlorine loses electrons at the anode, becoming electrically neutral, and these are transferred to copper at the cathode via the closed circuit. This unifies the idea of electrolysis much more than the present method of recording and subsequent interpretation.

The accepted method of balancing oxidation equations is by determining the electronic changes, but by the present way of expressing valence, it involves the transference of charges into electrons. However, writing the valences in this new way no transference is necessary.

$$\text{Old way: } \overset{+7}{K(Mn)}O_4 + \overset{-1}{H(Cl)} \longrightarrow \overset{0}{Cl_2} + \overset{+2}{(Mn)}Cl_2 \ldots\ldots$$

$$\text{New way: } \overset{-7\epsilon}{K(Mn)}O_4 + \overset{+1\epsilon}{H(Cl)} \longrightarrow \overset{0}{Cl_2} + \overset{-2\epsilon}{(Mn)}Cl_2 \ldots\ldots$$

It becomes at once clear that manganese has lost electrons to chlorine.

These few examples will serve not only to indicate the ready usefulness of recording valence and ions in terms of electrons, but to show that it is a more logical procedure in that it expresses the theory as we now accept it. With this view, the term *valence* would have little use. It might still be retained as a general term expressing combining power, but different terms for the strongly electropositive and electronegative elements ought to be used. These new terms should be as descriptive as possible of the condition of the atom when ionized, so that they could be easily applied by the beginning chemistry student. Several terms have already been suggested, that is hypo- and hyper-electronic, but these are rather lengthy ones. A criticism might also be made in that the method of always writing ϵ in designating valence is somewhat burdensome, but this would be necessary at present to differentiate the expression from that of positive and negative charges now in textbooks. Later the ϵ might be dropped and -2 would then indicate -2ϵ while $+2$ would indicate $+2\epsilon$.

To summarize, it should be emphasized that this method of recording valence and ions in terms of electrons would more accurately express the accepted theory, shorten and simplify the use of the electronic conception, and consequently be more useful to a first-year chemistry student.

Blistering War Gas Made from Corncobs. A blistering compound, or vesicant, very similar in its properties and action to the much-feared mustard gas of war-time fame has been prepared from corncobs by Dr. Henry Gilman and A. P. Hewlett of Iowa State College. It has also been shown that charcoal made from corncobs may find application as an absorbent in defensive gas masks. The full chemical title of the newly prepared blistering chemical is beta-chlorethyl-2-furfuryl-sulfide. It was not prepared in the first place with any idea of using it in war. The two chemists were looking for something that would put an unerasable mark on the hide of a hog, to identify it during its path of sorrow through the packing plant, preparatory to its metamorphosis into hams and side-meat. It seems to be very satisfactory for this purpose. It does not raise blisters on the porcine rind as it does on human skin, but merely makes red marks that will remain unchanged for at least twelve hours before killing. None of the original compound remains on the marks, so that it is safe for packing house employes to handle the hog. And just as the corncob charcoal could find use in war, so does it have a possible peace-time application with these same hogs. Fed to swine, it improves their digestion, possibly by absorbing troublesome internal gases.

Dr. Gilman and his associates have been carrying on a long series of experiments to find new uses for all parts of the corn plant. In the course of their researches they have evolved a great variety of substances of possible commercial value, including drugs, perfumes, flavoring extracts, and a compound sweeter than saccharin.—*Science Service*

TRAINING IN WRITING CHEMICAL EQUATIONS

JOSEPH I. OSER, SIMON GRATZ HIGH SCHOOL, PHILADELPHIA, PENNSYLVANIA

Most chemistry classes, in spite of labor and pain on the part of conscientious teachers, contain students who apparently can*not* understand the writing of chemical equations. To make up for this deficiency they often attempt to memorize all the chemical equations connected with the chemistry course. If anything tends as much as this regrettable procedure not only to deaden the student's interest but also to instil a deadly dislike for chemistry I should like to know what it is.

If students receive definite systematic training in equation writing, it should tend to improve their abilities along this line and eliminate "parroting" of equations.

Difficulties in Writing Chemical Equations

Having identified the reacting substances, one must know, or find out, or do, three things in order to write a chemical equation:

1. Ascertain the products of the reaction
2. Write the formulas of the substances involved.
3. Balance the equation.

The difficulties of equation writing, in the words I have heard many students use, are—

1. "I don't know what forms."
2. "I don't know the formula."
3. "I can't make it balance."

Most teachers will agree that the first is the biggest difficulty. The second is most easily overcome. The third can be conquered by special training which will be outlined below.

Let us now discuss these difficulties, and see what can be done about them.

"I Don't Know What Forms"

This difficulty is, indeed, a real one. The student must be enough of a chemist to almost sense the products of a reaction.

Aid can be given in developing this understanding by impressing a few (not too many) general rules. Thus—

1. Metal + Acid (not nitric) $\longrightarrow$ a Salt + Hydrogen (*Replacement*)
2. Metal Oxide + Acid $\longrightarrow$ a Salt + Water
3. Base + Acid $\longrightarrow$ a Salt + Water (*Neutralization*)
4. Most reactions among acids, bases, and salts result in double decomposition. If one of the products so formed is unstable it may further decompose (preparation of carbon dioxide, ammonia, sulfur dioxide, etc.).

Knowledge of rules like these, plus much practice in writing equations, often causes marked improvement in the pupil's ability to write chemical equations.

"I Don't Know the Formula"

Many students forget that chlorine, hydrogen, nitrogen, and oxygen contain two atoms to the molecule, and that their formulas are therefore written, respectively, Cl_2, H_2, N_2, and O_2. This should be driven home. It goes almost without saying that thorough drill in valence and formula writing should precede the writing of chemical equations. Since sodium and calcium compounds are used so frequently in high-school chemistry work, special attention might be given these. How many times have we seen $NaCl_2$ and Na_2Cl instead of NaCl; $Na(NO_3)_2$ and Na_2NO_3 instead of $NaNO_3$; $NaSO_4$ instead of Na_2SO_4. The secret of getting the correct response lies in drill, drill, and still more drill. The pupil who does the correct thing often enough finally gets to know it.

It should be impressed on the student that if a formula is written incorrectly, it will often be impossible to balance the equation; even if balanced it will certainly be incorrect.

As some one has said, "For want of valence a formula was lost; for want of a formula an equation was lost; for want of an equation a student was lost." However, it should be realized by both teacher and student that valence is merely an *aid* in writing formulas, and not an infallible scheme.

"I Can't Make It Balance"

Students are usually expected to acquire the knack of balancing equations on the wing, as it were. Many have the native intelligence to do this. That is, after they have watched the teacher balance two or three equations they can do it almost as well as he can. Where the knack of balancing is not so easily acquired, more specific instruction is needed. This should take the form of practice on carefully selected material of progressively increasing difficulty.

(1) By the time the writing of equations is begun, the course will probably have included the study of oxygen, hydrogen, water, and hydrogen peroxide—perhaps, also, of chlorine and hydrogen chloride. The aspiring chemist who has seen the combustion in air or oxygen of carbon, hydrogen, phosphorus, sulfur, magnesium and iron, and the burning in chlorine of hydrogen, phosphorus, antimony, arsenic, iron, and sodium has at his command a fund of chemical experience which should be utilized. If he has also learned that almost all other elements combine with oxygen and chlorine, there is at hand much material for the writing of simple equations. I suggest only a few examples (all requiring different procedures for balancing)—

Magnesium + Oxygen $\longrightarrow$
Hydrogen + Oxygen $\longrightarrow$
Aluminum + Oxygen $\longrightarrow$

Phosphorus + Oxygen ⟶
Hydrogen + Chlorine ⟶
Sodium + Chlorine ⟶
Iron + Chlorine ⟶

Beginning with such simple combinations, the unskilful student not only gets practice in both formula writing and balancing but even acquires some little confidence in his ability to name the products of reactions. Such confidence is helpful to success.

Considering the above as the most simple type of chemical change, other reactions useful for practice (in order of increasing difficulty) are:

(2) The production of hydrogen by the solution of metals in acids (except nitric). Examples for practice:

Zinc + Hydrochloric Acid ⟶
Magnesium + Hydrochloric Acid ⟶
Aluminum + Hydrochloric Acid ⟶
Iron + Sulfuric Acid ⟶
Zinc + Sulfuric Acid ⟶

(3) The solvent action of acids on oxides. Examples:

Zinc Oxide + Hydrochloric Acid ⟶
Ferric Oxide + Hydrochloric Acid ⟶
Silver Oxide + Nitric Acid ⟶
Aluminum Oxide + Sulfuric Acid ⟶

(4) Reactions showing double decomposition, especially neutralization. Examples:

Sodium Hydroxide + Hydrochloric Acid ⟶
Barium Hydroxide + Nitric Acid ⟶
Aluminum Hydroxide + Hydrochloric Acid ⟶
Aluminum Hydroxide + Sulfuric Acid ⟶
Silver Nitrate + Calcium Chloride ⟶
Silver Nitrate + Aluminum Chloride ⟶

(5) Reactions of double decomposition, with an unstable product (not within experience of and too difficult for beginners at equation writing). Examples:

Ammonium Chloride + Calcium Hydroxide ⟶
Ammonium Sulfate + Sodium Hydroxide ⟶
Calcium Carbonate + Hydrochloric Acid ⟶
Sodium Bicarbonate + Sulfuric Acid ⟶
Sodium Sulfite + Hydrochloric Acid ⟶
Calcium Bisulfite + Sulfuric Acid ⟶

Two Other Points to Be Considered

Two other points to be brought out are the following:

(1) The fact that an equation balances does not necessarily indicate that it is correct. Every chemical equation should represent an actual chemical change. Therefore, equations like the following are meaningless; they purport to represent changes which really do not occur.

$$NaOH + KOH \longrightarrow NaKO + H_2O$$
$$2Au + 6HCl \longrightarrow 2AuCl_3 + 3H_2$$

(2) After a formula is written correctly, according to the student's knowledge, it must not be changed to make the equation "easier to balance." Suppose a student begins an equation and has written

$$CaCl_2 + Ag(NO_3) \longrightarrow AgCl + Ca(NO_3)_2$$

It frequently happens that he then adds the subscript "2" after the Cl in AgCl, and after the (NO_3) in $Ag(NO_3)$—"to make it balance."

$$CaCl_2 + Ag(NO_3)_2 \longrightarrow AgCl_2 + Ca(NO_3)_2$$

The teacher should emphasize the fact that equations are balanced by changing *coefficients* and not *subscripts*.

A New Tendency—and a Poor One

In order to "make a good showing" in standard tests, some teachers and some textbooks begin the "teaching" (if it can be called that) of chemical equations with the very first chemical change studied, or else at the very beginning of the chemistry course. That is, with no chemical experience to draw on, and without definite knowledge of atom or molecule, symbol or formula, the student is expected to write equations using formulas throughout.

Since bright students can learn from any teacher, or by any method, they immediately do well with this scheme; and the class average jumps. Most of the class, in self-defense, adopts the memorizing of equations as the only alternative. They can then do more on the test paper; and not only the average, but also the median jumps. And thus is introduced something which should certainly be avoided. If anything tends to make the study of chemistry deadly dull, and abhorred, it is the mechanical memorizing of equations. There is no fun and no pride of achievement in doing equations in this way. (Of course, some who begin by memorizing equations later get rid of the habit.)

The very early introduction of chemical equations is defended on the ground that boys and girls are especially interested in and are attracted by formulas and equations. So, as in other ultra-modern educational procedure, the stunt is to let them play around and think they are doing big things, even if they do not understand what it is all about.

It often is better to put the "psychological before the logical" but, I respectfully submit, the writing of equations is one division of chemistry teaching where the cart should not be placed before the horse. Let the student learn some chemistry, let him learn about atoms and molecules, symbols and formulas, and then he may be able to write chemical equations in an understanding way.

THE CONFIGURATION OF THE MONOSACCHARIDES*

R. HARMAN ASHLEY, THE ST. LAWRENCE UNIVERSITY, CANTON, NEW YORK

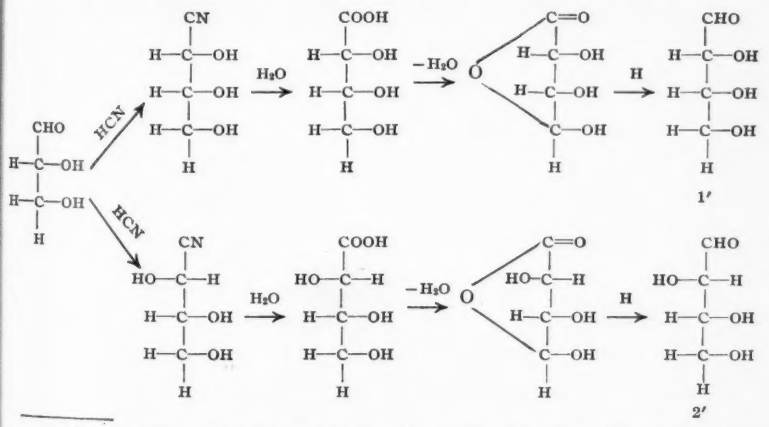
The Aldopentoses

The determination of the configuration of the monosaccharides when discussed before a class in organic chemistry presents some difficulties to the instructor if only the labor of writing the structural formulas on the blackboard and the considerable space required for this be considered. The following method of presentation has been successfully used at The St. Lawrence University with good results. The figures and, if need be, the reactions may be thrown upon a screen with a projection lantern.

Taking up first the aldoses, aldotriose, $CH_2OH{\cdot}CHOH{\cdot}CHO$, would be the simplest member and would exist in two optical isomers. Each of the aldoses likewise would have its optical opposite, so for the sake of simplicity only the dextro family will be considered, since the same line of argument applies to the levo family.

In Figure 1 (page 2132) the right-handedness of the *d*-aldotriose is shown by the symbol for the —CHOH group extending to the right With this substance as a parent, all the other members of the dextro aldoses may be regarded as having been derived. In conformity with this it will be noted that in Figure 1 all the bottom —CHOH groups in each and every derivative are represented as in the dextro form.

The method of lengthening the carbon chain to produce the next higher aldoses consists of the addition of hydrocyanic acid, the hydrolysis of the resulting cyanhydrin to the acid which changes over to the lactone, and the reduction of the latter to the aldehyde. Thus from *d*-aldotriose would be produced the aldotetroses 1′ and 2′ in Figure 1. The reactions are:



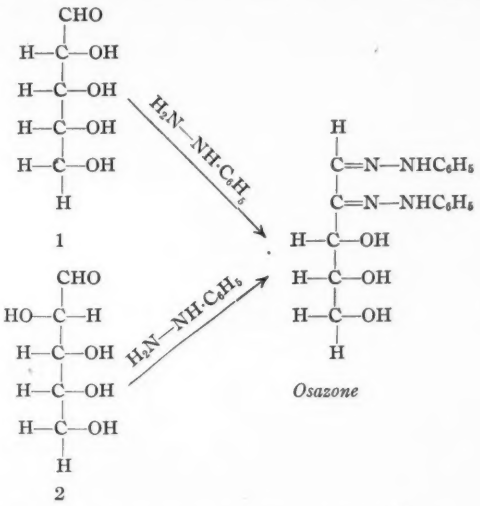
* The basic idea of the method of presentation of the configuration of the monosaccharides given herein was obtained from Reid's "College Organic Chemistry," D. Van Nostrand Co., Inc., New York City, 1929.

active
active
inactive
inactive
4
2'
3
symbols
○ = -CH2OH
△ = -CHO
⊗ = =N-N<H-C6H5
◎ = -COOH
⊢ = H-C-OH
active
active
active
inactive
2
1'
1
d-aldotriose
aldotetroses
aldopentoses
osazones
dibasic acids

Figure 1

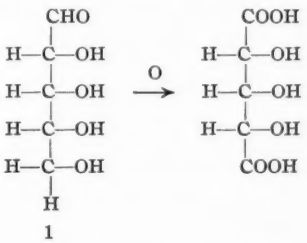
In a similar manner the aldopentoses, 1, 2, 3, and 4 of Figure 1 are derived. These are known as arabinose, ribose, lyxose, and xylose. The problem is to determine the configuration of these aldopentoses.

Arabinose and ribose on treatment with phenyl hydrazine produce the same osazone, hence, knowing that this reagent reacts with the —CHO group and the adjacent —CHOH group in forming the osazone, it follows that the configuration of arabinose and ribose must be identical for the end groups $CH_2OH{\cdot}CHOH{\cdot}CHOH{\cdot}$. The reactions for the formation of the osazones may be represented in the case of the aldopentoses 1 and 2:



Hence arabinose and ribose must be either pairs 1 and 2 or pairs 3 and 4. But which? This is represented in Figure 1.

Each of the aldopentoses may be converted into dibasic acids as exemplified in the case of the aldopentose 1:

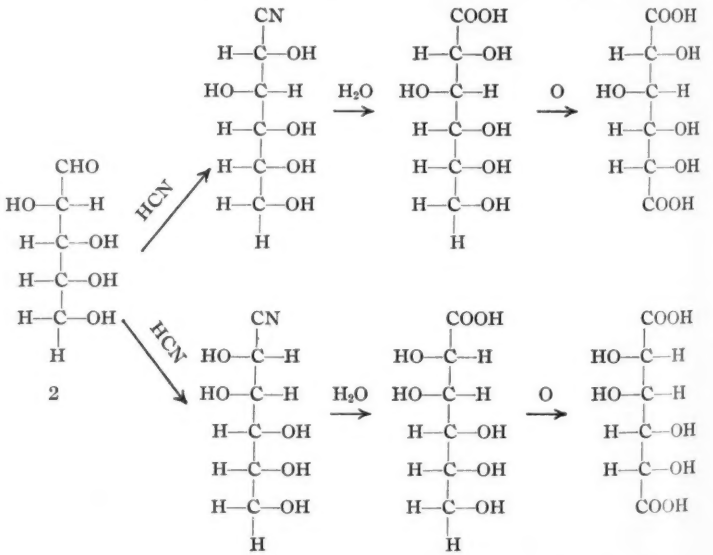


It will be noted that the above dibasic acid has only two asymmetric carbon atoms, those next to the —COOH groups. From the configurations

given it will be seen that optically active acids will be produced from the aldopentoses 2 and 4 (Figure 1) while the aldopentoses 1 and 3 would produce optically inactive acids due to internal compensation.

In experimental fact, arabinose and lyxose produce dibasic acids which are optically active. Ribose and xylose on oxidation produce optically inactive dibasic acids which cannot be separated into optically active opposites, hence the inactivity of these acids must be due to internal compensation. The dibasic acids produced from ribose and xylose are not identical. The dibasic acids derived from 1 and 3 would be optically inactive yet different acids. Hence, ribose and xylose are 1 and 3, but which is which? This leaves arabinose and lyxose for 2 and 4, but again which is which?

If the carbon chain of the aldopentoses 2 and 4 are lengthened by the addition of hydrocyanic acid, the cyanhydrins hydrolyzed to the acid and the acids oxidized to the dibasic acids, these acids would contain six carbon atoms. The reactions in the case of the aldopentose 2 (Figure 1) would be:



These syntheses are represented diagrammatically in Figure 1, from which it is seen that 2 would yield two acids, both optically active, while 4 would yield one optically active acid and another inactive acid (due to internal compensation).

In experimental fact, arabinose yields, by the above given transformations, two dibasic six-carbon atom acids, both optically active, while lyxose

by the same process produces one active and one inactive dibasic six-carbon atom acids. It follows, then, that arabinose corresponds to the configuration 2 which leaves configuration 4 for lyxose.

From the osazone evidence, if arabinose is 2, then ribose must be 1. Lyxose and xylose produce identical osazones, hence if lyxose is 4, xylose must be 3.

In presenting the above to a class it is only necessary to have Figure 1 before the class. The argument follows almost of necessity and the reactions given above will usually have been taken up with the class previ-

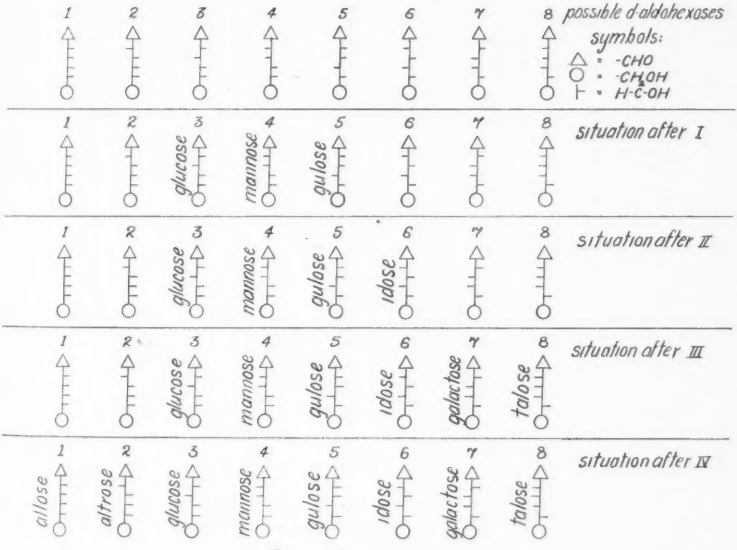


Figure 2

ously. If a projection lantern is available, the reactions are readily thrown on the screen which helps in the presentation.

The Aldohexoses

There are eight pairs of aldohexoses, of which only the dextro aldohexoses will be considered, as the argument would be the same with the levo aldohexoses.

The genesis of these *d*-aldohexoses may be worked out in a similar manner to the *d*-aldopentoses already considered. Eight aldohexoses are known:

Allose	Glucose	Gulose	Galactose
Altrose	Mannose	Idose	Talose

The problem is to assign to each its configuration. The eight possible *d*-aldohexoses are shown in the top line of Figure 2, numbered from 1 to 8. The configuration of the four *d*-aldopentoses has already been established. Beginning with arabinose, the argument would be as follows:

I. (See Figure 3). By acting on arabinose with hydrocyanic acid, hydrolysis of the product and reduction with sodium amalgam, glucose, and mannose are obtained, hence the structures of these are known up to the symbol ϕ which represents a secondary hydroxyl group which may extend to the left or the right. Configurations 3 and 4 satisfy this condition, hence

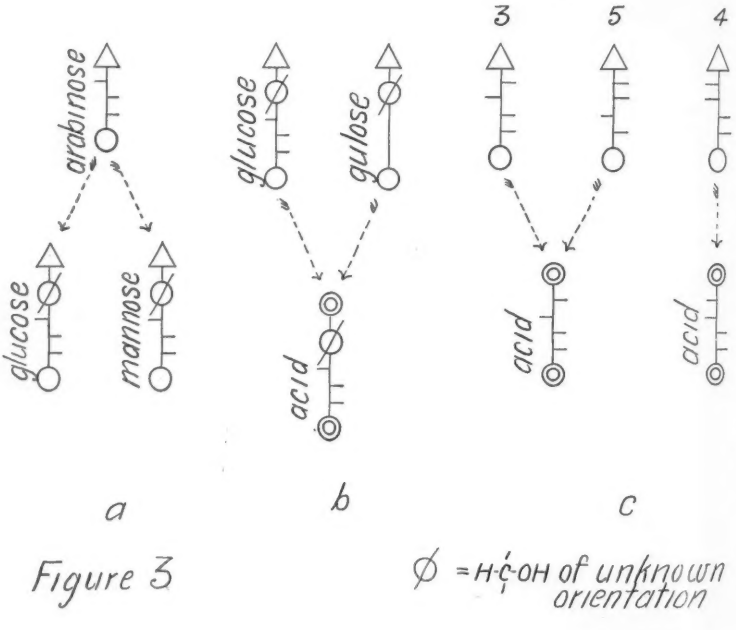


Figure 3

glucose is either 3 or 4 and mannose is the other. Figure 3 (*a*). It will be noted in Figure 3 that the secondary hydroxyl groups in gulose are not represented. This is to indicate that up to this stage of the argument, nothing is known about them.

Glucose and gulose on oxidation yield the same dicarboxylic acid, hence these two substances must have the same structure except that the aldehyde and primary alcoholic groups are transposed. From Figure 2 it is seen that 5 and 3 show this relationship. In experimental fact, the dicarboxylic acid obtained from *d*-mannose is not obtained from the oxidation of any other sugar. These facts are shown in Figure 3, (*b*) and (*c*). It follows then

that mannose must be 4, glucose 3, and gulose 5. Parenthetically, it may be added that glucose and mannose produce the same osazone. This fact is not needed in the proof of configuration as outlined.

II. Gulose and idose produce the same osazone, hence they must be alike up to the secondary hydroxyl group next to the aldehyde group, consequently, if 5 is known to be gulose, 6 fulfils this condition and idose must be 6. See Figure 4.

III. The structures unassigned are 1, 2, 7, and 8. See Figure 2. Galactose on oxidation gives an optically inactive dicarboxylic acid. Of the four structures left, only 1 and 7 would do this, hence galactose is either 1 or 7. But which? See Figure 5 (*a*) and (*b*) (page 2138). Galactose and talose with phenyl hydrazine yield the same osazone. By adding another carbon atom to galactose and oxidizing to the dicarboxylic acid, two optically active acids are produced. With this treatment 1 would give an active and an inactive carboxylic acid while 7 would produce two dicarboxylic acids, both active. See Figure 5 (*d*) and (*e*). Accordingly galactose must be 7 and from the osazone evidence talose is 8.

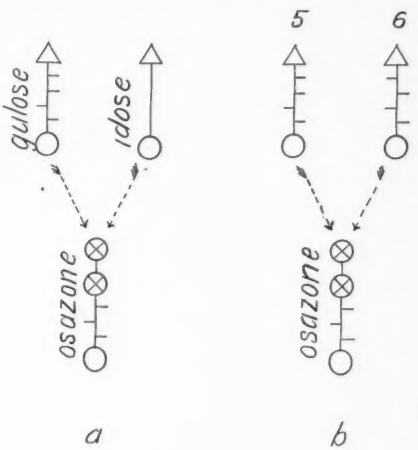


Figure 4

IV. *d*-Allose and *d*-altrose may be synthesized from *d*-ribose by the action of hydrocyanic acid, hydrolysis of the product, and subsequent reduction of the acid produced. Knowing the configuration of *d*-ribose, the structure of allose and altrose is known up to the secondary hydroxyl group next to the aldehyde group. Allose on oxidation produces an optically inactive dicarboxylic acid while altrose by the same process yields an optically active acid. See Figure 6 (page 2138). It is seen that 1 would produce an optically inactive acid by this process while 2 would produce an optically active acid, hence allose is 1 and altrose is 2. Allose and altrose give the same osazone.

The Ketohexoses

Knowing the configuration of the aldohexoses, the configuration of the ketoses follows readily from the fact that the carbonyl group in a ketose is always next to a primary hydroxyl group, hence phenyl hydrazine will form

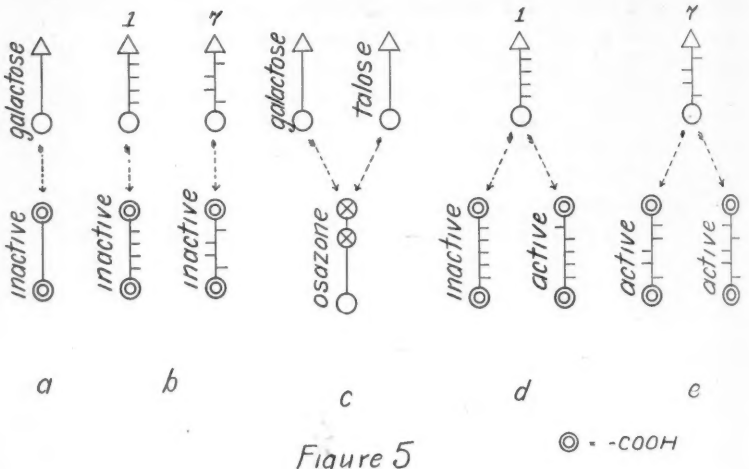


Figure 5

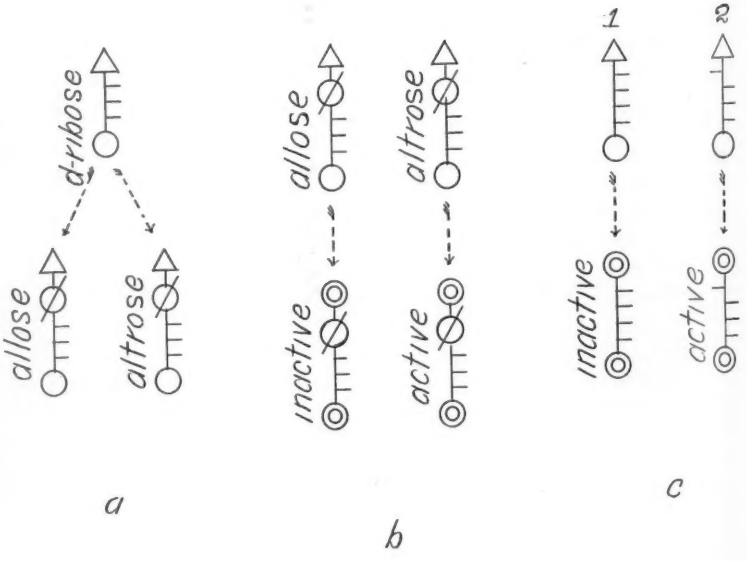


Figure 6

the same osazone from the aldose and the related ketose. Confining the argument to the dextro compounds, if *d*-glucose and *d*-fructose and *d*-mannose produce the same osazone, as they do, their configurations are alike except for the two end carbon atoms carrying the carbonyl group.

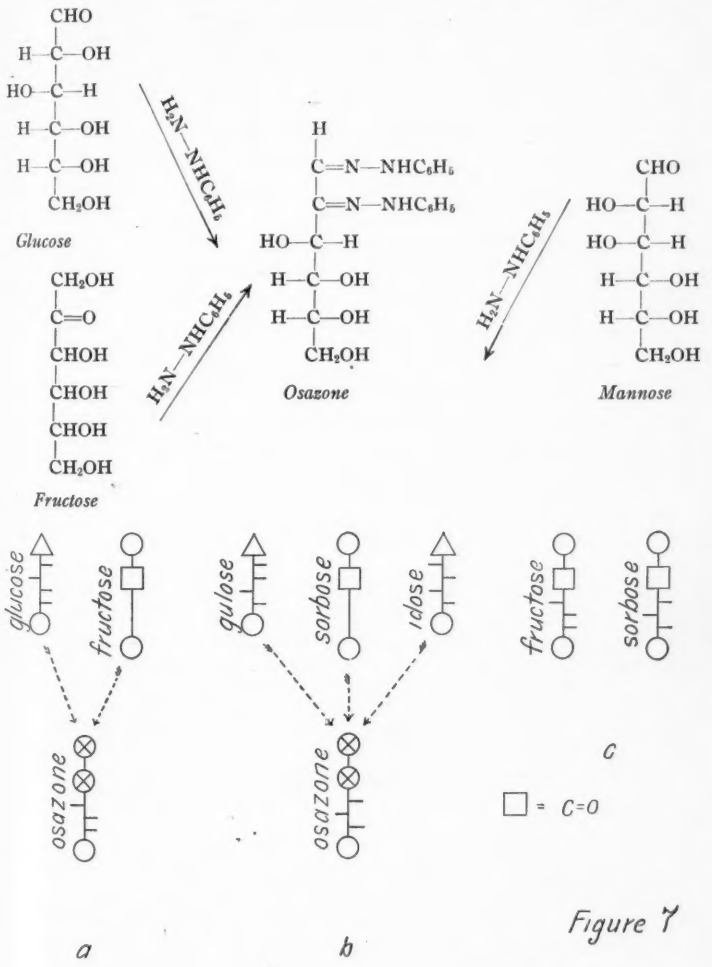
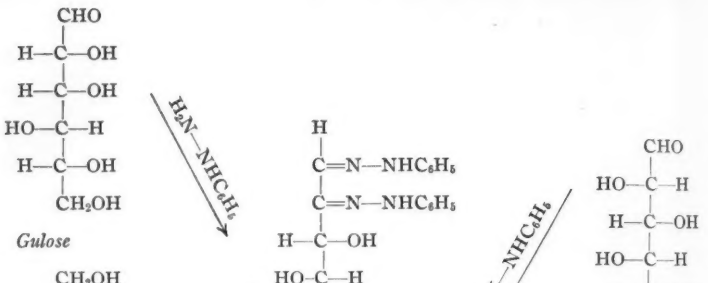


Figure 7

Fructose must have the configuration given in Figure 7. *d*-Sorbose and *d*-gulose produce the same osazone. This same osazone is also produced from idose:



Sorbose must have the configuration shown in Figure 7.

In the method of presentation of the configuration of the monosaccharides described above it is necessary to make some assumption, but after fixing one structure, all the others must be as given.

Methyl Chloride, Refrigerator Gas, Does Not Poison Food. Methyl chloride, the refrigerator gas held responsible for a number of poisonings during past months, is not likely to poison food or beverages if it leaks into the interior of a refrigerator. This is indicated by tests conducted at the U. S. Bureau of Mines laboratory at Pittsburgh, and announced recently by the U. S. Public Health Service. The scientists conducting the research were W. P. Yant, chemist, H. W. Shoaf, toxicologist, and J. Chornyak, medical officer. The tests were made at the request of one of the firms manufacturing methyl chloride.

Deliberate efforts were made to render food poisonous by exposing it to the gas in full concentration for many hours, and to poison the water by bubbling the gas directly through it—conditions which would never occur in any but the worst kind of internal leaks. Various kinds of food thus treated were fed to experimental animals, but those showed no ill effects.

Because water would absorb more methyl chloride than food would, a longer test was conducted with it. Water containing the gas nearly to the point of saturation was given to a group of experimental animals for a period of nearly six months, and although they sometimes showed signs of not liking the taste of it, they remained in apparent good health throughout the period. Only after they were killed at the end of the experimental period and their remains examined microscopically were any effects noted. It was discovered then that their kidneys showed some signs of strain from their long and severe service on the "poison squad."—*Science Service*

METHODS OF INCREASING INTEREST IN HIGH-SCHOOL CHEMISTRY*

ROBERT COLLIER, JR., SOUTH HIGH SCHOOL, DENVER, COLORADO

Take a postage stamp and stick it to a penny. Now climb Cleopatra's needle, 71 feet above beautiful Central Park, New York, and lay it flat, postage stamp uppermost on top of the obelisk. The height of the whole structure may be taken to represent the time that has elapsed since the earth was born. On this scale the thickness of the postage and penny together represents the time that man has lived on earth, the thickness of the penny representing the time he has lived in an uncivilized state and the thickness of the ink on the stamp then might be taken to represent the progress of man since the advent of chemistry. It scarcely seems possible that the earliest laboratory manual in this country is now only 83 years old, that until 1898 only 8.55% of high-school students were studying chemistry. Now we have about 82% of the number studying this vital subject. Chemistry has made more strides in the last ten years than in all of its previous history, and I, for one, believe that our method for presenting this wonderfully entrancing subject to our coming citizens has failed to keep pace with its rapid growth. With the wonders of chemistry coming into the lives and homes of every one today, through the radio, television, talking pictures, motor cars, airplanes, and the world of things that we consider commonplace, the future citizen must be aroused to the part that chemistry is playing in his life. No one can be considered educated without at least a foundation knowledge of chemistry. It must be made as much a part of the education of the modern man as English, history, mathematics, and other subjects now felt indispensable to modern citizenship.

A brief summary of conditions here at South High School may be somewhat enlightening. Last year from a graduating class of 236, 128 seniors had pursued the course of chemistry. Of this number approximately 100 have gone on to college. In college not more than twenty-five are taking chemistry, and of that number not more than three will ever make chemistry their life work. In other words, not over 1% of a high-school graduating class will ever develop into professional chemists. With these facts facing us, I believe that chemistry must be taught for the 99 others who will never come into direct contact with chemistry again. Further, it must be taught in such a way as to awaken interest, instil love and encourage a student to continue his interest in the subject in later life, rather than cause a hatred of chemistry in the mind of the youth of today, which will persist in the man of tomorrow. The sort of chemistry needed by the modern citizen is different from that required by those who make this subject their life profession. Complicated laws, solving of chemical

* Presented before the Division of Chemical Education of the American Chemical Society at the Atlanta Meeting, April 7–11, 1930.

formulas and problems have little part in the chemistry of a housewife or an average business man. However, the research, industrial, and factory chemist must understand and use these laws every day in his work. Thus, we find that the demand of chemistry on the industrial chemist differs radically from the demand on the lay chemist.

It must be admitted that in most colleges and universities, this subject is presented with the one idea uppermost in the mind of the professor, namely, to turn out chemists. Every person enrolling in the course is treated alike, given the same dose as it were. If it takes, he becomes a chemist; if it fails he is free to try something else. While this may serve the purpose of the various departments in cutting down the numbers graduating as chemists still I believe that if the department was functioning properly and if our colleges and universities were fully awake to the need of chemistry by the citizen of today, they would provide two types of chemistry. First: a course for those who want the subject as a matter of general education. Second: a course for those who, at least at that time, believe that they would like to follow chemistry as a life work. Much has been done in the past five years toward popularizing chemistry. Edwin E. Slosson (*1*) has done more than any other man in bringing chemistry to the lay chemist. His death on October 15, 1929, was a distinct loss to science. He made no great discovery along scientific lines, but he did discover something more rare; how to interest those without scientific training in the facts and accomplishments of science through his "Creative Chemistry," magazine articles, and finally as editor of *Science News Service*. This service furnishes to the papers of today authoritative statements on progress in all lines of science in place of the superstitious and ridiculous flights of fancy published not so many years ago in our papers, thus giving to our people actual facts that can be relied upon. Thus Mr. Slosson accomplished more toward bringing chemistry to the front in American life than any one else.

The American Chemical Society, through its presentation to Francis P. Garvan of the Priestley medal, has recognized the work that he has done toward increasing the knowledge of chemistry in the minds of the common people. His generosity in financing the American Chemical Essay Contest led, last year, to the writing of well over one-half a millon essays on chemical subjects by people who are not chemists. The effect of this on the lives of the people in causing them to think more along chemical lines cannot be estimated. With the impetus of the movement thus started, courses of popular chemistry, sometimes called pandemic chemistry, have begun to appear in many colleges and universities of the country, these courses being designed for those who wish a general understanding of chemistry and not a technical one. The courses are presented in a popular way and are so designed as to attract students. At present the

movement is not at all widespread but I believe that the next few years will see a considerable increase in chemistry of this sort.

Many books on chemistry are appearing with sugar-coated titles such as: The Triumph and Wonders of Modern Chemistry, The Romance of Modern Chemistry, Chemistry in the Service of Man, Chemistry in Industry, and Chemical Discovery and Invention in the 20th Century. Books of this type are finding a ready sale throughout the country, showing the increase in thought of the lay reader along scientific lines.

Mr. J. L. Sheean has stated the objectives of a course in high-school chemistry as follows (*2*):

1. To give a broad and genuine appreciation of what the development of chemistry means to modern social, industrial, and national life.
2. To satisfy the normal interest in the materials and forces of nature; to give information which is interesting purely for its own sake.
3. To promote opportunity for the student to become acquainted with the applications of chemistry to industry for the purpose of educational and vocational guidance and possibly to furnish a beginning of vocational training.
4. To develop broad concepts of the ultimate composition and indestructibility of matter, nature of chemical composition, interrelation of chemical elements, etc., to the end that science and reality may function in place of superstition and uncertainty in explaining natural phenomena.
5. To contribute such specific ideals, habits, and concepts as those of accuracy, achievement, persistency, open-mindedness, honesty, cause and effect which are essential to the study of science.
6. To develop system, order, and neatness, to the end that they will function in the ordinary affairs of life.
7. To afford in some measure an opportunity to show the importance of scientific research and stimulate the spirit of investigation and invention on the part of the student.
8. To give children full opportunity to indulge in the playful manipulation of chemical materials in order that they may explore the world of reality as widely and as deeply as possible.
9. To provide opportunity for acquaintance with such applications of chemistry in public utilities in problems affecting the health and well being of the individual and the community, that the student may more adequately fulfil the duties of citizenship. This would involve such topics as utilization of waste products, elimination of smoke, pure foods, etc.
10. To make pupils read more intelligently, and with greater interest, articles on chemistry in magazines and in scientific books of popular character.
11. To give such training as will result in increasing respect for the work of recognized experts.

Objectives of this sort are radically different from the usual objectives of the average course in chemistry. The aims, if arrived at, would not necessarily produce technical chemists but are bound to bring about a wider appreciation of chemical procedure and applications.

The teaching of high-school chemistry introduces many difficult problems; in the first place chemistry is rapidly becoming a required subject,

especially by those students who desire to enter college. Thus we must attempt to teach chemistry to all students who elect it regardless of the aptitude for the subject. The mental age of high-school students is growing lower every year. Students come into a course in chemistry, knowing nothing about the subject, simply to fulfil requirements for college entrance. In the second place the average high-school pupil knows nothing about real study of concentrated effort. Gone, apparently, are the days when William Henry Perkin worked for two years in fruitless endeavor on a chemical problem. The student of today feels abused if he must work ten minutes on a problem that he does not understand. In the third place we are compelled to compete with the great multiplicity of outside activities that take student's time away from our pet subject. Students have numerous clubs, music lessons, church, and social activities today as never before. The difficult subjects are bound to suffer through lack of preparation. The time is rapidly approaching when the school will be forced to provide supervised study. We cannot expect the preparation of assignments outside of school as we did in years gone by.

To face and overcome these major problems is a great challenge to the teacher of chemistry. He must make his chemistry suitable for the 99 out of every 100 who will never take up the subject again. It must be presented in such a way as to overcome all competition from outside activities and to create a real love and affection for chemistry which will last through life. If this true interest can be obtained, then the student will surmount all laws, and rules, which will later be found as obstacles to professional chemistry. He will get that vision of the wonderland of chemistry which will carry him through the drudgery which is often so deadly to those without the vision. Now if this is to be done a different approach must be obtained from the old style of chemistry teaching. This old method is one originally produced for the developments of chemists, and was started years ago when chemistry was in its infancy. The texts were written in most part by wonderful men who after years of study and effort produced the books. The same texts were rewritten, cut down, and revised for high-school pupils. However, this did not adapt them for the immature mind of the secondary student. Little do they care whether oxygen weighs 1.429 grams per liter, or that lead has a specific heat of 0.0305. Far more important to them is the fact that hydrogen used to be used in balloons and is now used to make oleomargarine and ammonia gas. Material must be presented in a modern way if it is going to stick and mean anything to the student in later life. The applications must be stressed rather than the actual physical and chemical properties of the various elements. Reading used to be taught by teaching the alphabet and from that the words. Now the alphabet is never taught, except incidentally. The same thing in a measure should be done in chemistry.

The uses of materials that affect the life of the student should be stressed rather than simply the building bricks of chemistry, namely, the study of the elements and their properties.

The foundation of a course is laboratory work. It is here the student at the start is given an opportunity to satisfy his curiosity and indulge in the interesting manipulation of chemical materials. This of course obtains the greatest interest fundamental to the teaching of chemistry.

Two possible methods of approach are given here. First: a test and class discussion of the materials in question are followed by a proving of textual facts by laboratory study. Second: careful directions leading to discovery of facts are then confirmed by text study and class discussion. The latter method I believe is the better because the student does not know what to look for and must therefore work more slowly and carefully than when he is merely checking up on what the text indicates. This method is not always possible in the organization of the classes and laboratory periods, but I believe accomplishes the best results whenever it can be used. Class and laboratory work must be closely correlated at all times. Further, as much practical experimentation should be brought into the laboratory work as possible. Experiments that can be used outside the classroom and those that even verge on the spectacular for parties and entertainments are all worthwhile. Many times experiments from various popular science magazines are brought in by the students and performed in the laboratory.

We allow students to come in at any extra period that they care to for work. The laboratory is open from 7.45 A.M. until 4.30 P.M. every day and at no time is a student barred if he has extra work that he cares to perform.

Written reports are required for every experiment performed. Extra credit is given for additional experiments beyond those of the regular course.

Many teachers believe that the writing of chemical experiments is a definite waste of time but I have been unable, as yet, to devise any means of securing careful, thoughtful, and observing work in the laboratory unless these reports are required. We demand that the reports of experiments be neatly written in ink, in good English, and turned in within one week from the date the experiment was performed. Late experiments are penalized 10 points for each day late. This results in experiments being written up promptly while the work is still fresh in the minds of the student. I do not favor laboratory manuals which are more or less indicatory of the result to be obtained, but at the present time most manuals are written in that style. Some difficulty, of course, is always noticeable among students who rely on others to do their thinking for them, but in chemistry, as in no other work, the opportunity is given to encourage

honest, thoughtful work on the part of the individual pupil. During the year we perform approximately fifty separate experiments not counting the thirty problems of qualitative analysis. A great deal has been said in favor of lecture-table demonstrations but personally I believe the pupil will learn more from his own experience with the materials in the laboratory than from observation of the teacher's work.

The use of factory exploration trips is a device that aids markedly in creating an interest in chemistry. For a student to leave the atmosphere of a classroom and go down to a factory where materials are being produced and to follow the manufacturing process from raw material to finished product is an experience long remembered. There are many objections to this method. First: poor guides, who know nothing of the chemical procedure, are often obtained and an erroneous impression of the true process is given. Second: most chemical changes take place inside of large tanks and very little of the real process can be seen. Third: an attitude of holiday spirit enters and many factory managers believe, with perfect right, that this spirit has no place inside a busy factory. It has been my experience, however, that this latter objection can be overcome by a thorough understanding of what is expected of the pupil before the trip is started. All factory trips should be followed up with written reports and classroom discussions, which thoroughly fix the process and its importance on the mind of the student, so that the mere mention in later life of the article which was made in that factory brings up immediately the part that the chemist played in its manufacture, if not the actual chemistry involved. This to me is the desirable result. In Denver we do not have many factories, so much of this experience must be obtained in a different way: namely, by the use of the motion picture.

I am an enthusiast on the subject of the value of motion pictures as a part of the teaching process. In many ways a student will learn more from a good motion picture film than from a factory trip. The films are shown in a classroom, free from the distractions of the factory, the thunder of the machinery, the poorness of the guides, and the natural timidity of the pupils to ask questions, as a regular part of the class work. The new types of industrial films available show first by photographs and then by diagrams the entire process involved. This serves to impress the process as nothing else will, and further tends to vitalize the whole process in the lives of the student. Such films as "The Making of Rayon Silk," "Paper," "Steel," "Bakelite," "Carborundum," "Glass," "Cement" are all types of splendid educational films. All of these subjects have a definite chemical basis and while some processes are beyond the scope of discussion in elementary chemistry, still the student will realize that the part of the chemist has been fundamental in the production and manufacture of these materials.

The chemistry party is another device which I have found pays handsome dividends for the work involved. Any subject which can be turned into a game is bound to get a certain amount of interest from the student and this interest of course is spread to other pupils in the building who do not take chemistry. In the past our chemistry parties have consisted of chemical guessing games, contests, chemical plays, and races involving chemical terms and formulas. Some people believe that such work contributes little to the actual learning of chemistry. Any device which obtains interest in a subject cannot fail in obtaining an increased knowledge of it.

Another method of obtaining interest, though not strictly along chemical lines, is the annual sport trip which our sections take every January. For the past six years we have made trips to Estes Park for snowshoeing, tobogganing, and skiing. These trips at least serve to obtain a better understanding between pupil and teacher and have resulted, many times, in better work in chemistry.

Speakers are obtained from the outside to address all students taking chemistry. Speakers must be carefully chosen and must speak on subjects that the immature high-school pupil can understand. When a subject is presented by an outside speaker, the material given often means more than when given by the teacher with whom they come in contact every day. Such men as Dr. Gustavson and Dr. Engle have addressed our sections with marked success. I only wish more men of their type were available.

The chemistry club idea has at times proved of considerable value. Many pupils are willing to devote considerable time in the preparation of demonstrations for use before a chemistry club. This of course means a great deal to the student working the experiment, but is of relatively little value to the onlooker. Such demonstrations as the use of liquid oxygen, manufacture of nitrogen by the Birkeland-Eyde process, the testing of the heat value of coal, the measurement of a molecule, are all of interest to high-school students. The chief difficulties in connection with such an organization are the place of meeting and time for meeting. Most parents object to night affairs during the week and no time is available during school. Many work after school so that such meetings are difficult to hold.

For the past six years the American Chemical Society Essay Contest has furnished a splendid means for obtaining large amounts of reference reading outside the textbook. We require a 1500 to 2000 word essay on one of the six topics given in the contest to be written by each student as part of the chemistry course. This results in many mediocre essays written to fulfil the demand of the teacher, but numerous splendid reports are produced. The student has gained as much from the preparation of such an essay as from any other one thing in the chemistry course.

At the close of the course in chemistry we spend the last six weeks in the laboratory in an elemental course of qualitative analysis. It is not the purpose of this course to develop chemists. We attempt to review thoroughly the fundamentals of equation writing, the chemical properties of many of the common materials with which we come in contact, and finally to sum up the whole subject that has been studied during the year. Thirty separate unknowns, ranging from solutions to simple salts, are given to each student to work out in the six-week period. Additional work in the laboratory is encouraged for the better students and it often becomes a problem to get rid of pupils whose interests lead them to spend two to three times as much time in the laboratory as their normal program requires. The work, of course, is absolutely individual, and the game spirit enters in very largely. The students receive an unknown, test it, and report to the teacher the result. The second unknown is then received. Whenever a student appears to be guessing, results which they get must be shown to the teacher. If a student has failed to do fair work throughout his course the qualitative analysis usually proves his downfall. However, very few fail at this time of the year. Qualitative analysis many times gives a student the desire to continue chemistry further in high school. This has resulted in giving, for those who wish it, an advanced course in chemistry. To date the school authorities have refused to grant high-school credit for work of this nature and have also refused to permit teaching time for the proper instruction for those who wish to continue the work. In spite of these difficulties, each year finds a few people who think enough of chemistry to elect laboratory time for advanced work along such lines as testing coal, simple gravimetric and volumetric analysis, study in colloid gels, and occasionally some ore analysis is undertaken. This work is all done individually, conferences with the teacher being held whenever parts of the experiment are reached where the student is unable to continue alone. Much splendid work has been done in the past. I believe that such work is of great value, especially in this age of obtaining a direct return for every effort put forth. Here a student obtains no credit toward graduation, the only reward being the satisfaction that comes from work well done.

Many interesting and instructive exhibits of chemical processes and products are available from manufacturers all over the country. We have recently received exhibits from the Continental Oil Company, Ideal Portland Cement Company, The Bakelite Corporation, Corn Products Company, The Carborundum Company, and others. These exhibits are of definite value and cause considerable comment and discussion in the classes where the material is presented.

Various publications of the American Chemical Society are extremely valuable in aiding a teacher to keep up with the rapid advance of chem-

istry in its many branches. The *JOURNAL OF CHEMICAL EDUCATION* and the *Chemistry Leaflet*, which were recently taken over by the Chemical Foundation, are very useful when a teacher is pushed for time by the many requirements of the school. It oftentimes is extremely difficult to do as much reading as he should in order to keep abreast of the times. These magazines are splendid means of bringing to mind many facts which are valuable in a course in chemistry, and which would possibly be omitted were it not for these splendid publications.

To sum up briefly the important phases of high-school teaching, I would say that high-school chemistry must be presented in a manner which will secure a life-long interest in chemistry and the chemical applications which are so important today. This interest, once thoroughly secured, will result in many pursuing chemistry as a life profession, while the great majority that do not make their livelihood along chemical lines will have that appreciation and love of chemistry which will stay with them throughout their lives. This cannot be accomplished by the methods used in so many schools today where they aim to fit students for the demands of colleges and universities. If this appreciation can be obtained then I feel that high-school chemistry will richly repay all those who study the subject, whether for those intending to enter the profession or those who need chemistry as a part of their general education.

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British See Sand as Source of Helium for Airships. Monazite sand, source of thoria from which gas mantles are made, may provide the lifting power for future British airships. Work at the Chemical Research Laboratory at Teddington by R. Taylor has shown that this sand is a possible source of helium, the non-inflammable gas that now replaces hydrogen in American airships. The United States now has a practical monopoly of helium which is found in extractable quantities only in the natural gas of certain American gas wells. Large quantities of monazite sand are available in the British Empire, especially Ceylon and Travancore, India.

The natural gas from Texas contains about one per cent of helium, while the monazite sand yields about 1 cubic centimeter of helium to every gram of sand. This means that to fill a ship of 5,000,000 cubic feet capacity, the size of the R-100, newest of British dirigibles, 150,000 tons of sand would have to be refined. The gas escapes from the sand on heating, so in treating it for the manufacture of thoria large quantities of helium are wasted. In the process for its refinement worked out by Mr. Taylor, the gas is treated with heated magnesium metal which removes most of the nitrogen, and then final treatment with heated calcium removes the rest of the nitrogen and other gaseous impurities.—*Science Service*

DOES THE COLLEGE TEACHER IN GENERAL CHEMISTRY NEED TRAINING IN EDUCATION?*

JACK P. MONTGOMERY, UNIVERSITY OF ALABAMA, UNIVERSITY, ALABAMA

The question of the relation of high-school chemistry courses to college chemistry courses is an ever-present one in the minds of most college teachers. Probably no subject in the field of chemical education has been discussed so much with as few conclusions reached. For many years the trend of the discussions was along the line of how the college teacher could help his high-school brother, usually considered as a young and inexperienced brother, in the matter of building up his courses, equipping his rather meager laboratory, and adapting high-school chemistry to the supposed needs of the boys and girls. In the southern states, at least, this was the case during the first twenty-five years of the present century, and it is probable that in all sections, except in large population centers, a similar condition prevailed. The past ten years, however, have provided a decided revolution in high-school chemistry teaching in all sections where, as in the south, high schools have so rapidly multiplied. No longer is there a chance for college chemistry departments to dominate high-school chemistry either as to methods or material. Indeed, except for the indirect influence which busy college teachers have upon their pupils who afterward become high-school teachers, college chemistry departments are not highly regarded by the high-school force. This is especially true of the college general chemistry course in the eyes of the high-school teacher. State Departments of Education are tending more and more to the requirement that all high-school teachers shall have had a certain number of semester hours in the college of education of the institution from which they hold a degree. In most of the universities the college of education follows the trend by outlining a curriculum which not only leads to the bachelor's degree but includes the requisite education courses indicated by the State Department. In most cases not more than sixteen semester hours are taken in the department of chemistry. It is true, however, that more chemistry is encountered in courses in secondary education, directed teaching, and teaching science in the high-school courses, but these courses are given by the college of education and the student is under the dominance of that faculty.

We have the condition, rapidly growing stronger, that not only high-school teaching but the preparation for that profession, so far as chemistry is concerned, are very slightly within the purview of our college departments of chemistry. It may easily happen at almost any university that a student elects biology the first year, general chemistry the second, and then, in the third year, takes organic chemistry, secondary education, and either principles of instruction or directed teaching. If he has done

* Presented before the Division of Chemical Education of the American Chemical Society at the Atlanta Meeting, April 7–11, 1930.

good work in his general chemistry under a capable teacher it is to be presumed that he has been well grounded in theories and principles and that his motivation in chemistry, both in relation to daily life and to commerce and manufacture, has been along the line of the application of study and research to the betterment of mankind. Purely descriptive matter has had little place except as illustrative of the application of principles. It is even likely that the course has had a definite disciplinary value. If in the year following such a course he is given work in education, say in teaching of science or in directed teaching under men who are thinking education, with a big E, rather than chemistry, it is likely that he will conclude that his chemistry course was inexpertly taught, and he may be correct in that. If he is taking organic chemistry coincidently with his education he is almost sure to conclude that the department of chemistry and the college of education are not on speaking terms. The result in the case of such a student, if he later teaches chemistry in high school, is that methods and motivation become his bywords. He thinks more of methods of presentation than the mastery of what is presented, and motivation comes to mean more and more the awakening and increase of interest in what chemistry has brought to pass, a listing of blessings due to chemistry, rather than the study of chemistry itself. Multiply this case sufficiently and it is not hard to understand some present conditions. Students who elect chemistry in the high school are undoubtedly handled in a highly specialized manner so far as method and motivation are concerned. It is just as undoubtedly a fact that they are handled according to what is the orthodox manner as taught by the colleges of education. But when these students enter college classes in general chemistry they usually find a different attitude on the part of the teacher whose attention is upon the science of chemistry rather than the science of education. The failure of many fine high-school chemistry students to progress in college chemistry may be taken as evidence that either the college teacher or the high-school teacher is in error, or perhaps they need to understand each other better.

Under present conditions very few college chemistry teachers are interested in education courses. On the contrary, professional education is changing so rapidly in some of its phases that the person primarily interested in natural science views the science of education somewhat askance and is not always polite in his references to it. Also, under present conditions, the high-school man is so strictly the product of a system that he can offer little initiative in bridging the gap or closing the breach between high-school and college chemistry. If anything is to be done it will have to be from the side of greatest freedom, the college side. Does the college teacher in general chemistry need courses in education? He does if, in the generosity of his greater freedom, he desires

to perform the two-fold service of sending out high-school teachers of greater usefulness and of making chemistry more easily continuous for the high-school student when he enters college. Such courses carefully taken by the college man will enable him to intelligently criticize the work of the college of education in teacher-training work and directed teaching. Such criticism may lead him to change his own methods or it may lead to a lively combat in which he seeks to deliver a likely chemist from an impossible situation. If he decides to fight the education people he will have at hand weapons which they will feel. He might even convince some of them. If he concludes that the education people are right in their present methods, then like a true man of science, he will join forces with them and use the educational material at hand for the building of a greater teacher. But perhaps all this is hardly worthwhile for the turning out of teachers, merely, so he may seek another reward in the students who come to his own college classes. After all, the most valuable college teacher is the one who understands not only the subject in which he is interested but the men and women before him, their difficult adjustments, their enthusiasms, and even their mistaken ideas about things precious to the teacher.

Perhaps the college teacher is at the present time fully able, in chemistry, to help the student make his adjustments which are so difficult, keep enthusiasms high, and happily set his feet on the right track. Such a teacher does not need courses in education, but he is of the minority.

Indium Made Pure by Electrolysis. The curiosity metal, indium, only about a pound of which has been isolated from its ores, is produced 99.9 per cent pure by electrolysis. Although it is very rare and what little there is of it brings for experimental purposes about six times as much as platinum, scientists are hopeful that a use will be found for its peculiar properties. It melts at a much lower temperature than tin and is very soft and ductile. Electrolysis separates it from the residues of such ores as iron, aluminum, titanium, and silicon, where it is found in small quantities, L. R. Westbrook, of Cleveland, recently told the American Electrochemical Society.—*Science Service*

Pneumonia from Inhaling Gasoline. Experimenting, boylike, with a rubber tube and the gasoline tank of an automobile, an eight-year old lad got an unexpected dry cleaning of his lungs, which resulted in pneumonia, when his companion blew on the other end of the tube. The case was recently reported to the American Medical Association in Chicago. When the other end of the tube was blown into, the gasoline was forced into the boy's mouth. He choked and had a severe strangling spell, from which he recovered, but pneumonia developed. For four weeks he could taste gasoline and it could be smelled on his breath. Gasoline is rapidly absorbed by the lung tissue, the report stated. The pneumonia that follows this absorption is not typical. The fever is not high and the rapid breathing continues for a long period. The inflammation of the lungs does not remain in one spot, but wanders about, suggesting that the gasoline fumes also wander about in the lung tissue, setting up inflammation in other spots.—*Science Service*

HIGH-SCHOOL AND COLLEGE CHEMISTRY

F. H. Edmister, The University of North Carolina, Chapel Hill, N. C.

The success or failure to teach chemistry properly in the high school, or anywhere else for that matter, depends obviously upon several factors: the training of the teacher; the preparation and ability of the student; and the facilities in the way of laboratories and equipment.

The training of the teacher is summed up in his ability, natural and acquired, to impart instruction to the student, and his grasp of the subject which he is to teach.

There are a few "born teachers," but the great majority enter the profession without any divine call to it; and so we have professional courses in the colleges and normal schools which are designed to acquaint the prospective teacher with certain fundamental principles and theories of teaching. In all states and counties a considerable number of such courses must have been studied before a license to teach is issued, the number of such courses depending upon the grade of license sought. The teacher must also have done a prescribed amount of teaching under the supervision of an experienced teacher, who criticises the conduct of his work. There are no exceptions to these requirements. Whether or not the lesson plans of various types are followed later by the instructor, he must have become acquainted with what is conceded to be the best methods of instruction.

On the other hand, there seems to be no semblance of a uniform requirement as to the number or quality of courses in the subject matter. This is left to the discretion of the superintendent. Unfortunately, ideas as to the necessary amount of preparation in this line are so different, and the practice is so varied, that almost any possible situation may exist.

The number of hours to be given to chemistry in college, according to several schedules examined, is six. This means that only the elementary courses can be taken in the time allotted to all the work for the four years, and the number of hours prescribed for the professional courses far exceeds that given to the chemistry.

It surely must be apparent to every experienced teacher that no one is qualified to teach any branch of learning until he is at least conversant with the subject as a whole; and yet here we have a situation where a great part of the teaching of chemistry in secondary schools is in the hands of teachers who have only a very elementary knowledge of the subject.

It is very unfortunate that so few of our B.S. graduates in chemistry enter the field of teaching in the secondary schools. One reason, if not the chief reason, for this is the impossibility of registering for both the required professional courses, and the subject courses in chemistry which the student feels he must take, in the four years at his disposal; so he must choose between the two. If he chooses the teachers' course he will be deficient in knowledge of his subject; if he chooses the subject courses he

is eliminated from the high school, and either goes into industrial work or into private school teaching where the requirements do not rule him out. The poorer student goes to the high-school job.

In these days of progress and advancement, the up-to-date high school attempts to ape the university and add course after course to the curriculum until it is overloaded with all manner of strange and unrelated studies, and the student is dismayed at the array presented for his assimilation. Quantity and not quality is the goal, and the student arrives, let us say, at the time and the place to take up the study of chemistry but knows very little about arithmetic beyond the multiplication table, and is unable to grasp the essentials of the subject. When this combination occurs, a poorly prepared teacher and a poorly prepared student, it is not strange that the "problem of the problem" is most easily solved by the simple process of elimination, and the student meets this stumbling block for the first time in his class in the university. The value of the use of problems in teaching chemistry can hardly be over-estimated; but for a college instructor, the attempt to use them with students who flounder around in fractions, percentage, and proportion, generally results in the despair of both. A student who has not learned to apply the simple principles of arithmetic will have a difficult time with chemistry.

There is another consideration which has a bearing upon the teaching of chemistry in the high schools in many localities, which perhaps can best be expressed in this way: many universities are not fortunate enough to have a sufficiently large teaching staff to divide the freshmen into divisions of those who have had a course in high school, and those who have not. The mixed class is then unavoidable, and unfortunate, particularly for those with some knowledge of chemistry. It is the usual experience that these students, or some of them, will assume that this knowledge will carry them through at least half of the first term without studying; and when the awakening comes it is too late to recover the lost ground. It is noticeable that the less the actual knowledge, the greater the assumption.

There is considerable criticism in regard to the teaching of mathematics in the secondary schools, and judging by the lack of ability in the students in chemistry there would seem to be some ground for the criticism. Be that as it may, there are many college instructors who would like to see more time spent in the high school upon arithmetic and algebra at the expense, if need be, of chemistry, leaving that to the college. The results would almost inevitably check with those found at Syracuse (*1*); *viz.*, that the high-school grades in mathematics gave a better index to the ability of the student than the grades in high-school chemistry. Given a good thorough ground work in simple mathematics, the understanding of the principles of chemistry becomes a relatively simple matter.

The writer knows that these remarks do not apply to all high schools, nor to all universities. Undoubtedly in some sections the interrelation is satisfactory, but in other localities there is room for improvement along these lines and it is the hope that steps may be taken to make these improvements.

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RELIEF FOR THE OVERWORKED HIGH-SCHOOL CHEMISTRY TEACHER

FRED FORDEMWALT, PARSONS JUNIOR COLLEGE, PARSONS, KANSAS

Many teachers of high-school chemistry find themselves burdened with such a heavy schedule that they find it impossible to do much reading of current science topics. The result is a tendency to become dissatisfied and disappointed with the complete lack of personal progress. To offset this situation the following simple procedure has been followed in the high school of Parsons, Kansas, with steadily increasing success and satisfaction, both on the part of teacher and students.

Friday of each week is set aside as a day for the presentation of special topics of scientific interest. On this day each student is expected to report to the class some article which he or she has read in the past week. It has been found best not to limit the subject matter to any specific topic, but merely to scientific subjects. The first five or ten minutes of the period in this method is given to outlining the work for the coming week. This simple process has met an excellent response and has resulted in the production of many very fine student papers, covering a wide range of topics. An encouraging factor is the increasing excellence of the selection of reading material made by the high-school students.

Mme. Curie Doubts Change in Rate of Decay of Radium. Doubt that radium and allied substances can be made to change the rate at which they decay into other elements is expressed by Mme. Marie Curie, discoverer of radium, in commenting on experiments by L. Bogojavlensky which were supposed to show such a change. In 1750 years half of a given quantity of radium will have changed into radon, or radium emanation, and helium. Mme. Curie points out that very careful precautions are necessary before any change in this rate can be established. She has made a number of experiments herself, on radium, radon, and polonium, another radioactive element, by exposing them to the action of various rays, and has not been able to find any evidence of a change in rate.—*Science Service*

RESEARCH PROBLEMS OF HIGH-SCHOOL CHEMISTRY INSTRUCTION

A Committee on Research Problems of High-School Chemistry Instruction was established in 1924 by the Division of Chemical Education of the American Chemical Society, and functioned until its discontinuance in 1929. During its existence, one of the chief projects of the committee was the compilation of a bibliography on high-school chemistry instruction, this bibliography to be ultimately published in bulletin form. The Executive Committee of the Division of Chemical Education, at its meeting in January, 1930, voted to order the Mack Printing Company to distribute the type of the articles being held by order of the above-named committee. The list published herewith is of the articles for which type was distributed. It does not represent by any means a comprehensive survey of articles on high-school chemistry instruction appearing in the JOURNAL OF CHEMICAL EDUCATION during the years of the committee's existence. The publication of this list was referred to in the minutes of the Atlanta Meeting, lines 10–23, on page 1352 of the June, 1930, issue of THIS JOURNAL. All references are to the J. CHEM. EDUC.

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Behavior of Catalyst Studied by Chemists. Catalysts, the go-betweens that promote all sorts of fruitful and profitable chemical matchmaking in modern laboratories and factories, without themselves becoming parts of the compounds they help to create, have had their own hitherto mysterious character looked into lately. At the Atlanta Meeting of the American Chemical Society, Prof. Arthur F. Benton and T. A. White, of the University of Virginia, reported on some new things they have learned about the way catalysts act, especially at very low temperatures. They worked with finely divided nickel, which is one of the most widely used of catalysts, and hydrogen, one of the commonest of industrial gases, at temperatures ranging as low as 220 degrees below zero centigrade. The volumes of the gas adsorbed to the nickel under the conditions of the experiment led the chemists to the conclusion that adsorption takes place in two stages. In the primary stage the metal sheathes itself in a layer of gas molecules to the thickness of one molecule. When this envelope is complete, the gas molecules are more highly "activated," that is, more ready to combine into new compounds, than at any other time. Before the layer is complete, the catalyst may attract and hold patches of gas molecules, but they are too tightly held to be available for combination purposes. After the layer is complete, other secondary layers may form outside it, but these appear to be less under the influence of the catalyst and are therefore more indifferent to opportunities for forming combinations.—*Science Service*

100-Year Old Iron Puddling Gives Way to Machine. The man-powered puddling process of making wrought iron—the method used almost exclusively for the past hundred years of producing this tough, rust-resisting metal—is now giving way to the ingenuity of man and machine. Dr. James Aston, of the Carnegie Institute of Technology of Pittsburgh, has found a way to make wrought iron in large quantities with machinery and his method is being applied commercially in the manufacture of pipe, the U. S. Bureau of Standards announces.

For years the production of wrought iron exceeded that of steel. Then came the Bessemer process, and steel could be made so cheaply that it quickly replaced wrought iron for practically all purposes. Men had to make wrought iron by hand, slowly "puddle" it in a small reverberatory furnace. Metallurgists tried in vain to find a commercially successful mechanical method. Then Dr. Aston began to experiment in a mill at Warren, Ohio. And the Bureau of Standards has found that his product equals wrought iron in practically every respect although it is made by an entirely different process. Dr. Aston's wrought iron gets its fibrous slag structure by the pouring of Bessemer purified pig iron into molten slag made in an open-hearth furnace. Excess slag is squeezed out by a hydraulic press.—*Science Service*

IMPORTANCE OF BIOLOGY IN CREATIVE CHEMISTRY

WADE W. MOSS, JR., CERESINE INTERNATIONAL PRODUCTS CO., COLUMBUS, GEORGIA

A young man recently did me the honor of consulting with me about his graduate work at a southern university. He is majoring in organic chemistry or, let us say, in biological chemistry. When I questioned him as to his future plans, he advised me that he planned to work in the south, to do his bit to help in this new era of southern prosperity.

* * * * *

The south today is developing industrially. Such an impetus has been gaining as to be overwhelming. Great manufacturing centers are springing into being as the result of the work of the creative chemist. The whole creative work is essentially one of utilization of farm wastes. The southern farmer is the primary object. His prosperity is reflected in the South as a whole. Fundamentally, the South is agricultural. It has natural resources beyond any other section of the United States. But these products of nature are undeveloped. In many instances they are indigenous to certain southern localities, and cannot be grown elsewhere. A possible monopoly, if you please.

A number of creative scientists are utilizing these farm wastes, these local products, to economic value. For instance, the peanut is the very backbone of southwest Georgia. In the South the average farmer heretofore has raised cotton; rather not raised it, but attempted it without success. The boll weevil has become so destructive that it will not be long before the southern farmer will be unable to earn even the most meager livelihood from cotton. Many have already taken to peanuts.

The business man of the South wants to know what to do with all the peanuts which will be raised when every farmer whose land is suitable begins to grow peanuts. His answer is from the creative chemist, one who has training not only in chemistry but in botany as well. The industrial man will want a new article to manufacture. For example, let us say that there is a tremendous increase in growth of peanuts, so much in fact that the confectioner can just about utilize all the meats, in making his candy. What of the mountains of peanut shells? The production cost expert will begin to figure these shells as a large portion of profit and loss. Then he will appeal to the chemist for a chemical product which may be manufactured locally at a price competitive with some other article, let us say, similar to that which may be created from the peanut hull.

What, then, are the requirements of the chemist who will do this work? First, he will of necessity have to be a botanist, or at least possess a knowledge of vegetable histology. That is, he will have to make a thorough study of the cells of the peanut shells. He will do as much work under the microscope as he can. Then he will make his analysis chemically. Now he knows what constitutes the individual cells. He has his background.

What next must he do? Create something! Let us see how he would do this, for instance, from the peanut hull.

Theoretically, he would separate out the cellulose into the alpha and the other celluloses. Beside this he would place his pentose sugars; perhaps even hydrolyze them into their constituents, xylans, arabans, etc. Then, he would separate out his oil. Of this he may go so far as to break it up into its constituent fatty acids and the glycerides; or even go so far as to look for psytosterols, vitamins, carotinoids, etc. His proteins are taken out and lined into order; then decomposed into their respective amino acids. The tannins are gotten out. The remaining sugars are tested and identified. The sort of nitrogen is estimated and lined up, whether it is amide, free, or whatever manner of combination it happens to be, combined within the peanut hull. Next he has some ash; this he breaks down into whatever it is—phosphoric acid, potash, iodine, and the like. He has broken down the peanut hull.

Not yet is he through. Again he reverts to his biology. He has yet to study the fiber of cotton, hemp, spruce, and slash pine to determine, by comparison with the fiber of the peanut hull, its possibility as rayon stock or as paper fiber. He must investigate the purpose and function of the different celluloses within his individual hull. His work must show him, by virtue of his biology, the condition and the variation of the sugars in the hull under many circumstances. This is a job in vegetable histology and with the microscope. Another task for him which concerns both his chemistry and his biology is the effect of the age, for example, upon the xylans in the peanut hull. There is a real difference. This vitally concerns any finished product which relies on the sugars as it governs the percentage yield.

When he estimates on his vitamins, he brings into play some more of his biology. Or, in working with the proteins and the amino acids, he gets into his physiological chemistry. Or with his starches and sugars, with a view toward making fermentation products, bacteriology dovetails in.

In any creative work for the utilization of organicals in industry, the finished product is the result of biology as much as of chemistry. Any chemist working with the usual vegetable substances of the farm finds himself face to face with the carbohydrates, gums, glucosides, tannins, proteins, and so on. Try if you can to create a new product that the world has never seen before without making first a biological study of the raw material and it will be realized that the production engineer has something to say. For some reason, not known to himself, a great variance of yield will prevail, certain peculiarities will crop up continuously in the processing. The whole efficiency of the product will be lessened. The rebound strikes the creative chemist.

* * * * *

To this young man, who consulted me, I suggested that he learn as much biology, that is, botany, and vegetable histology, as he can. He will need it. Unfortunately, he had never studied bacteriology. He must do that above everything if he would succeed in this work. Attempting to do creative work in industrial biochemistry without a knowledge of botany is as improbable as attempting to work with plants without knowing the different families to which they belong.

The industrial South has much to offer the trained college man with a profound knowledge of biochemistry, a creative ability, and a knowledge of botany, vegetable histology, and bacteriology.

Gas Masks for Mines. The use of gas masks for respiratory protection against poisonous gases in industrial processes has been gradually increasing during the past ten years, their development having been advanced by the impetus given by war-time requirements; but for mine-rescue purposes the self-contained breathing apparatus, carrying its own supply of oxygen or air, has been the only reliable protection from poisonous gases available in this country.

With the discovery of hopcalite, a specially prepared mixture of manganese dioxide and copper oxide which converts carbon monoxide into carbon dioxide, it has become possible to make gas masks which give protection against afterdamp, provided there is sufficient oxygen present in the air to maintain life, and in the United States a gas mask, the "all service" mask, has been approved by the Bureau of Mines and has been used in mine rescue work with considerable success.

Close coöperation is maintained between the British Safety in Mines Research Board and the United States Bureau of Mines under a scheme which provides both for the carrying out of joint researches and for the exchange of investigators who are specially skilled in particular subjects. Under this scheme Dr. S. H. Katz, chemist-in-charge of the Bureau of Mines Gas Mask Laboratory, came to this country in April, 1928, and for just over a year joined with a member of the Research Board's staff in carrying out investigations in the Board's laboratories at Sheffield with the object of designing a mask which would be as efficient as the "all service" mask but would offer appreciably less resistance to breathing.

An account of these researches is now published by the Safety in Mines Research Board under the title of "Mine Rescue Apparatus: The S. M. R. B. Gas Mask," by S. H. Katz and C. S. W. Grice (S. M. R. B. Paper 57, H. M. Stationery Office, price 9d. net). The paper appears to show the possibility of the introduction of a light gas mask to take the place of self-contained breathing apparatus in support work during mine-recovery operations, if not in pioneering work.

Although the mask was designed primarily for mining purposes, it is hoped that it may prove suitable for the use of firemen and other workers who are liable to encounter poisonous gases in the course of their occupation.—*Chem. News*

Beryllium in Austria. It is announced that important beryllium fields have been discovered near Koeflach, in Styria, Austria, and that a half interest is to be acquired by the General Electric Corporation of America, which intends, owing to the importance of the deposits, to cease production in its Dakota mines.—*Chem. & Ind.*

PHYSIOLOGICAL CHEMISTRY FOR MEDICAL STUDENTS

MAX TRUMPER, UNIVERSITY OF PENNSYLVANIA, PHILADELPHIA, PENNSYLVANIA

The medical student attends classes on the average of 50 hours a week for 30 weeks a year, which is equivalent to a total of 3000 hours of pre-clinical instruction. Of this time he spends 150 hours in the chemical laboratory and 120 hours in lectures on chemistry. This approximates 9% of his pre-clinical studies or only 4.5% of his medical education, exclusive of his internship.

Therefore, the teacher of physiological chemistry must concentrate on the fundamental principles of chemistry in order to enable the student to understand and apply this tool to medicine. The immediate duty of the teacher is to teach the chemistry which has a direct bearing on medical problems and to avoid recent enthusiasms. The latter must of necessity be uncertain until the experts themselves have ceased to differ. Lectures, quizzes, and laboratory work all have their place. In the lecture the broad fundamental aspects of physiological chemistry should be taught and supplemented by well-planned demonstrations. A lecture which simply gives mere facts that can be learned from any textbook is of little help to the student. The student should be led to see the relation of physiological chemistry to other medical subjects as bacteriology, hygiene, pathology, and especially physiology. Moreover, there is a necessity for coöperation of the chemistry department with that of physiology and with the clinical laboratory since much of the subject matter dealt with in these departments overlaps.

Modern chemistry is so extensive and specialized that careful selection is necessary to obtain a balanced course. The same thing is true of chemistry as of the teaching of surgery to the undergraduate student. He is not taught surgery with the idea of graduating him as a finished specialist in surgery. He is made acquainted with the general principles of surgical technic, particular emphasis being placed upon diagnosis. The student should be made sufficiently familiar with the principles of chemistry and with the use of chemical apparatus to enable him to follow and apply subsequent advances in the field of medical chemistry. One can teach only that which he knows and if the teacher of chemistry has not had hospital or clinical experience, then the student will not be instructed along clinical lines. Clinical insight requires only an intermediate chemistry and not the pure theoretical chemistry of the research worker. In this connection I quote the following from Professor Harvey Cushing's dedicatory address on February 23, 1925, at the Yale Medical School.

> Fortunate is the school in which, from the outset, teaching is in terms of the future patient rather than of the present frog and guinea pig. But we clinicians, particularly those on the surgical side, begin to be a little doubtful of the existing program. We find that the two preliminary years of training in laboratory methods, conducted by teachers who themselves have had no clinical experience, fail to provide the student

with the information, resourcefulness, and observational training that would be most useful to him in his later semesters.

Whenever teachers pride themselves on the complicated formulas which their students know, it is probable that their knowledge ends with those formulas. And when medical students are required chiefly to solve complicated chemical problems, they are receiving a one-sided training. I do not intend to detract from the value or the necessity of accurate scientific teaching, but when a medical student is showered with intricate details on recondite chemical problems then no time is left to include the practical chemistry of clinical medicine. This should include pre- and post-operative chemistry, the chemistry of water balance, normal and abnormal nutrition and metabolism, the biochemical factors in pregnancy, the biochemical mechanisms in acidosis and alkalosis. The study of diet should include the inorganic constituents as well as the ketogenic-antiketogenic calculations.

The primary object of teaching is to find our way into the mind of the student and fix there the fundamental methods of acquiring scientific knowledge, supplemented by a working knowledge of the chemical necessities of the practicing physician and surgeon. The student should be given selected materials and methods which he can understand and apply. The theoretical disputable material incident to the advances of the pure science of chemistry must be avoided. The chemistry, for instance, of the possible interactions responsible for the development of the blue color in blood uric acid analysis is useless—all that the medical student need know is the advances in blood chemistry which were made possible through colorimetry and the principles involved. The medical student who acquires a glib acquaintance with the minutiae of fundamental research is too ready to substitute theoretical interpretations for sound substantial clinical thought and observation of his patient.

In the laboratory the more detailed work should be considered—here ideas are tested, methods demonstrated, and familiarity of the varied tests and apparatus obtained. Here an insight is afforded into the specific chemical alterations of the body in health and in disease. The student learns the significance as well as the limitations of laboratory tests. He should know when to have certain tests made, how to collect and to preserve the necessary specimens.

Today, more than ever before, owing to the flood of chemical researches, the teacher must judge critically the literature. Any chemist with clinical experience knows the too frequent assumptions that are made in transferring to the patient experimental studies made on animals. The mind of the student may be confused unless care is exercised in labeling experimental data and stressing their limitations. The complicated chemical subjects such as H-ion concentration, colloid chemistry, enzymes, and acid-base equilibrium can be presented in their physiological application with

more benefit to the student than if they were discussed from the abstract standpoint of the test tube and the reagent bottle. Chancellor Avery of the University of Nebraska has said:

> If I were teaching chemistry in a medical school, I would try to show the connection between chemistry and medicine even while teaching the subject as a general scientific course, thus stimulating the students' interest in chemistry through suggestions of its importance to their future work.

In thus emphasizing the importance of applied medical chemistry, I have assumed the knowledge of the principles of chemistry to be a prerequisite of the medical course. The present trend is to increase the pre-medical requirements in chemistry and this fact makes all the more important and all the more certain that the future chemistry of the medical school shall be definitely clinical chemistry.

The work for the freshman year should be restricted as far as possible to the chemical composition of the body tissues and fluids with a thorough consideration of the chemistry of foods, their digestion, absorption, and excretion. The work in the second year should be of a more advanced nature involving quantitative analyses of blood and urine in normal and pathological conditions. Particular attention should be given to intermediate metabolic principles which will enable the student to understand and apply the various clinical laboratory procedures to distinguish functional disorders from pathologic ones. The course offered to the freshman medical student should include the following:

1. Principles of physical chemistry in their application to physiological chemistry, including colloid chemistry.
2. Thorough presentation of enzymes and enzyme action.
3. Foodstuffs: carbohydrates, proteins, fats and lipoids, vitamins, inorganic.
4. Digestion: salivary, gastric, pancreatic, intestinal, bile.
5. Absorption.
6. Composition of blood and lymph.
7. Acid-base equilibrium.
8. Excretions: urine, feces, perspiration.
9. Human and cow's milk.
10. Tissue chemistry: epithelial, connective tissue, teeth, muscle, nerve, bone, etc.
11. Spinal fluid.
12. Putrefaction products.

The following should be considered for the sophomore year:

1. Resumé of digestion and absorption.
2. Intermediate metabolism (normal and pathologic), protein, fat, carbohydrate, inorganic, lipoids.
3. Quantitative blood analysis (normal and pathologic).
4. Quantitative urine analysis (normal and pathologic).
5. Water metabolism including water balance.
6. Vitamins, hypervitaminosis, and avitaminosis.

7. Chemistry of the endocrines.
8. Energy metabolism (normal and pathologic).
9. Gastric analysis.
10. Disturbances of acid-base equilibrium.

New Refrigerator Gas Is Fireproof, Non-Poisonous. A new gas for the coils of electric refrigerators was demonstrated at the Atlanta Meeting of the A. C. S. It is non-poisonous and non-inflammable, and it very closely approaches the refrigerating engineer's notion of an ideal substance for the purpose. The new gas is a compound of carbon, chlorine, and fluorine, and is a chemical cousin to carbon tetrachloride, widely sold under a variety of trade names and used for such diverse purposes as grease-spot remover, fire extinguisher, and insect exterminator. Carbon tetrachloride is one of the two ingredients that are used in making it, the other being antimony fluoride. The new refrigerant is the invention of Thomas Midgley, Jr., developer of ethyl gasoline, and a Belgian chemist, Dr. A. L. Henne. The work was done in the laboratory of one of the large electric refrigerator companies at Dayton, Ohio.

The new gas is as completely non-toxic as carbon dioxide, which we have in our lungs all the time as the result of our breathing and which we swallow whenever we drink any kind of carbonated beverage. Animals kept in an atmosphere containing a considerable percentage of the new refrigerant showed no signs of distress or illness. It is also completely non-inflammable; even with the addition of 30 per cent of butane, an exceedingly explosive gas, the mixture refused to ignite. These two qualities will recommend it to the average householder, who has been alarmed—more than necessarily, perhaps—by reports of refrigerant leakages causing poisoning. The refrigerating engineer finds comfort in the boiling point of the compound, which turns from liquid to gas at 28 degrees centigrade below the freezing point of water. This is about as low as he wants it, yet not too low. Another technical advantage is the relative chemical inertness of the gas. It causes slight corrosion of duralumin and bronze, but does not attack steel, iron, brass, copper, aluminum, or glass.

Like its parent substance, carbon tetrachloride, the new gas consists of one atom of carbon linked to four other atoms. In carbon tetrachloride the other four are all chlorine atoms; in the new gas two of them are chlorine and two are fluorine, a closely related element. The compound might therefore be called carbon-dichlor-difluoride. It has not received a name as yet, and for trade purposes will probably be given a less cumbersome title. It is chemically possible to produce other compounds with either one or three fluorine atoms replacing the chlorine, or even a complete carbon tetrafluoride; but for practical refrigerating purposes the two-chlorine, two-fluorine compound seems to be best.

In presenting his results, Mr. Midgley paid tribute to the work of a Belgian worker in theoretical chemistry, Prof. F. Swarts, who pioneered in the field of fluorine compounds. "It is doubtful if it had not been for the work of Dr. Swarts whether the present work would have been at all possible," he said. "It is certain that it would have been delayed for an indefinite period. This constitutes another example of the already numerous cases where industrial development has been reared upon the foundation of pure science research."

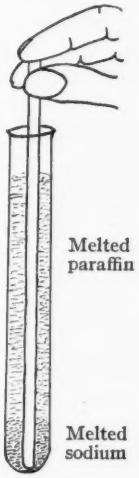
The commercial production of the new refrigerant will probably develop rapidly enough to bring it into the field after about two years, it is estimated. It is expected that this new compound will have an important part to play in the schemes which are now being developed to make houses more habitable in the tropics and in the intemperate summers of the temperate zones.—*Science Service*

A METHOD FOR DETERMINING THE HYDROGEN EQUIVALENT OF SODIUM

DRULEY PARKER, SHORTRIDGE HIGH SCHOOL, INDIANAPOLIS, INDIANA

In the past the writer has experienced considerable difficulty in weighing metallic sodium with any degree of accuracy for the purpose of determining its hydrogen equivalent. The determination of the hydrogen equivalent of sodium, magnesium, and aluminum is made as an introduction to the study of valence and subatomic structure. Inasmuch as a poor determination may do more harm than good it is important that the quantity of sodium should be weighed rather accurately.

Recently, Fernelius and Schurman (*1*) described a method for filling tubes with the alkali metals. They also suggested the use of such tubes as a means of securing accurate quantities of sodium. By the measurement of the bore of a tube and the calculation of the area of the cross-section; the length of the tube necessary to supply a given weight of sodium is found by dividing the amount of sodium by the product of area of the cross-section of the tube and the density of sodium.*



FILLING TUBES WITH METALLIC SODIUM

The method of filling the tubes as described by Fernelius and Schurman was modified by the writer as follows. A rather long narrow pyrex test tube was filled to within 15 mm. of the top with melted paraffin. Metallic sodium, reasonably free from oxide was dropped into this tube of melted paraffin and melted in the bottom of the tube under the paraffin. Glass tubing of 3 *mm.* diameter and approximately 75 *mm.* longer than the test tube was closed tightly with the forefinger and introduced through the paraffin into the melted sodium (see accompanying figure). The forefinger was removed and the tube filled with sodium due to hydrostatic pressure. The forefinger was again placed over the end of the tube and the latter removed to the air where it was held until the sodium had solidified. The lower end of the tube was of course sealed from the air by the melted paraffin solidifying. The tube was then cut off at the upper surface of the sodium and sealed with paraffin.

Paraffin is kept out of the tube as it is introduced, due to the air expanding. Several tubes can be filled in a few minutes by this method.

* The method of estimating the amount of sodium used depends upon the accuracy of measuring the diameter of the tube. If the diameter of the tube can be measured accurately to within 0.1 mm. the volume of gas evolved will check the data presented. Using the usual millimeter rule the diameter of the tube cannot be estimated much closer than 0.2 mm., hence about twice as much deviation in the volume of gas evolved from the mean is to be expected. This error is not sufficiently great to outweigh the convenience of the method.

It does not require a vacuum, an inert gas, or glass-blowing operations.

Lengths of these tubes were cut such as would give one-tenth gram of sodium, and the hydrogen equivalent was determined with this quantity. To determine the hydrogen equivalent, a water-filled gas-measuring tube was inverted in a large crystallizing dish of water and the tube clamped into position on a ring stand. A three-inch length of rubber tubing was plugged at one end and the cut length of sodium-filled tube slipped in at the other. This was then manipulated under the gas-measuring tube and the hydrogen collected. A short piece of copper wire bent at right angles served to dislodge any bubbles that get caught in the tube and shut off the water.

The following table gives the results obtained by four different teachers of our department, using the method as a lecture demonstration.

Volume of hydrogen	*Temp., deg. C.*	*Pressure*	*Volume at standard conditions*	*Hydrogen equivalent*
52.5	19.5	731.17	47.2	23.6
53	21.5	723.9	46.75	23.8
58.5	24	719.85	50.8	21.5
52.9	20	720.64	45.8	24.27
55.2	21	723.54	48.8	23.14
54.8	22	728.37	48.6	22.9
		Average		23.3

This method has the merit of being rapid, easy in manipulation, and gives more accurate results than the old method of weighing the sodium directly. The tubes are easily filled and may be conveniently stored.

Literature Cited

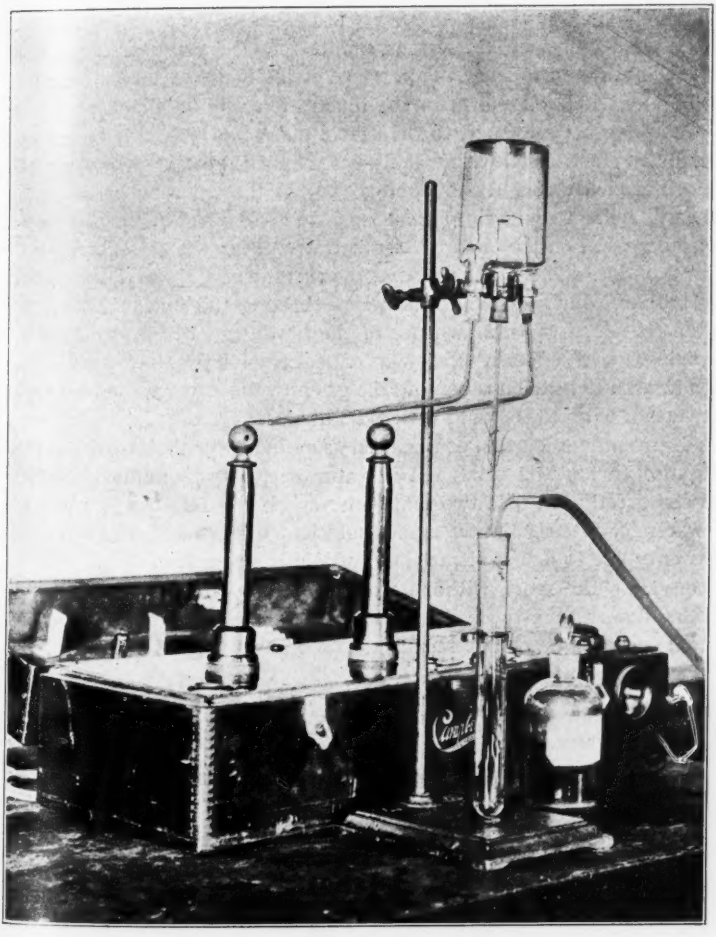
(*1*) FERNELIUS and SCHURMAN, "A Method for Showing the Metallic Luster of the Alkali Metals," J. CHEM. EDUC., **6**, 1765–6 (Oct., 1929).

Notebook of Early Manchester Chemist, Dr. W. Henry. Valuable facts about the work of Dr. W. Henry, the Manchester chemist, and a friend of John Dalton, have come to light by the discovery of one of his old notebooks, which was recently saved from destruction by a furnace attendant at the works of A. & S. Henry & Co., Ltd., of Manchester, who found it among some litter he had been instructed to burn. A paper on the subject was given at a meeting of the Literary and Philosophical Society, Manchester, by Mr. W. Buckley. The notebook contains many of the laboratory records of experiments which Dr. Henry described in a paper read in 1818, entitled "Experiments on Gas from Coal, Chiefly with a View to Its Practical Application." The doctor was frequently asked his opinion on points about the manufacture and use of coal gas at the mills, and several of the entries in the notebook relate to the difficulties that arose and his experiments in connection with them. Among the final entries, which concerned experiments to be carried out at a later date, is one suggesting the use of finely divided platinum for the analysis of gases by preferential combustion.—*Chem. Age*

A SHORT AND EFFECTIVE DEMONSTRATION OF NITROGEN FIXATION

M. Marcus Kiley, Technical High School, Springfield, Massachusetts

The formation of nitric acid from air and water is being demonstrated to our chemistry classes by a simple apparatus shown in the accompanying



Set-Up for Nitrogen-Fixation Demonstration

illustration. Within a forty-minute class period nitrate ion can be made in sufficient quantity for each member of the class to detect its presence by the Hehner ring test.

The operation consists in drawing the air out of a spark gap into water. The apparatus requires only electrical equipment for making the spark, some copper wire, a three-necked bottle, a ring stand and clamp, some glass and rubber tubing, rubber stoppers, a large test tube or wash bottle, and a means of reducing air pressure, preferably an aspirator. [See accompanying photo.]

Neutral litmus solution, ferrous sulfate solution and concentrated sulfuric acid are used to show the presence of the hydrogen and nitrate ions.

The induction coil shown in the illustration was originally part of an X-ray apparatus presented to the school and could probably be replaced by a much smaller coil with equally satisfactory results. The wires from the coil are led through glass tubing into the three-necked bottle so that they will be kept rigidly in place and be closer together at the gap than at any other point on the circuit. Air is drawn out of the bottle through the central outlet. This air is replaced by a fresh supply coming in through glass tubing which surrounds the wires entering the bottle. Absorption of the combined gases drawn out of the bottle can be improved by surrounding the absorption tube with a beaker of ice water, using a tube with small aperture for admitting the gas into the solution, and increasing the surface within the liquid with glass beads.

Neutral litmus solution can be used as an indicator to show the increase in hydrogen ion and turns red in from one to two minutes. Drawing the air directly out of a two-centimeter spark gap into one hundred mils of water for fifteen minutes makes sufficient dilute nitric acid for a class of twenty-five to detect nitrate ion by Hehner's ring test.

Operating the spark without drawing the air out of the three-necked bottle allows the nitrogen dioxide to collect in a few minutes so that its brown color can be readily seen against a white background.

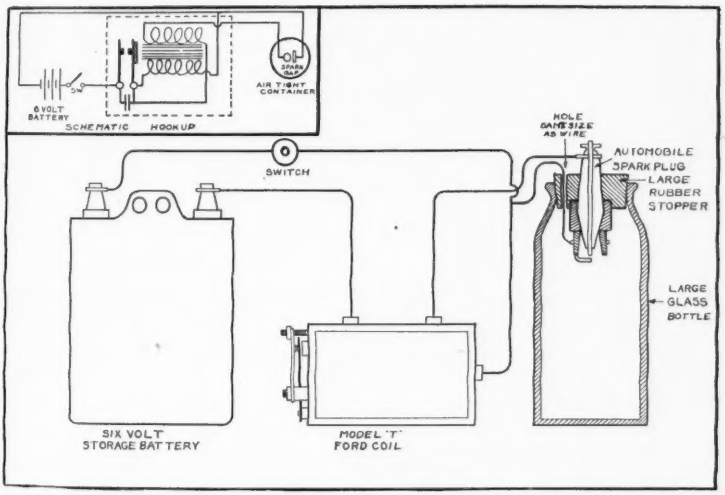
Three Hundred Fifty Tons of Nitrogen Taken from Air Daily. The largest nitrogen fixation plant in the western hemisphere, which greatly increases the industrial and military independence of the United States, was described by Prof. Lauren B. Hitchcock, of the University of Virginia, before the American Chemical Society at Atlanta. This plant converts daily 350 tons of inert nitrogen gas of the atmosphere into sodium nitrate and anhydrous ammonia for peace-time industrial uses. But if the United States were at war, the plant would largely free her of the necessity of getting Chile saltpeter from South America for fertilizer, explosives, and essential chemical industries. The plant is a splendid example of the application of recent refinements in process. Application of the latest technology is necessary in order that the synthetic material may compete with the Chile product dug from the surface of the ground. It is located at Hopewell, Virginia, on the James River, 80 miles from Hampton Roads.—*Science Service*

A DEMONSTRATION OF ELECTRIC NITROGEN FIXATION FOR HIGH-SCHOOL CHEMISTRY*

DORR M. SIMER AND MARY G. BROCK, SENIOR HIGH SCHOOL, DECATUR, ILLINOIS

In any demonstration of electric fixation that we have seen, an especially designed apparatus was used, thus making it rather impractical for the high school. In this modification, parts which are easily secured have been substituted and good results are obtained at less expense. This demonstration has been adapted from one given in a well-known high-school text.[1]

A group of students under the direction of the authors set up the



apparatus as a chemistry project, according to the accompanying drawing (by E. Vandeventer).

A Model T Ford coil was connected with a six-volt battery and with a Ford spark plug. The plug and the necessary wiring were fitted into a No. 5 rubber stopper which was inserted into the neck of a dry olive bottle (see drawing). When the circuit was closed, the spark jumped the slightly widened gap of the plug. After about ten minutes the brown nitrogen peroxide could be seen, at first only near the plug but later occupying the entire bottle. After about twenty minutes the circuit was broken and a few cubic centimeters of water were added. On shaking, the brown color disappeared and the liquid gave positive tests for nitric acid.

* This set-up won first prize in a demonstration contest sponsored by the Illinois Association of Chemistry Teachers at Granite City, April, 1930.

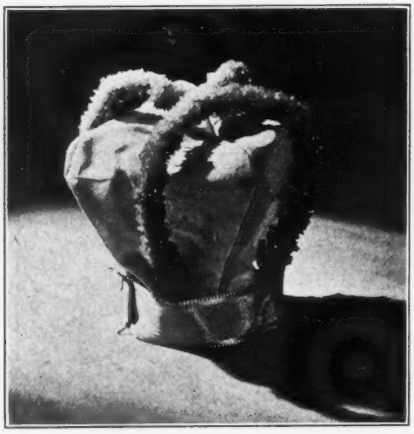
[1] DINSMORE, E. L., "Chemistry for Secondary Schools," F. M. Ambrose & Co., New York City, 1925.

SOME EXPERIMENTS IN CRYSTALLIZATION

CHARLES H. STONE, ENGLISH HIGH SCHOOL, BOSTON, MASSACHUSETTS

When a dilute solution of a crystallizable solid is allowed to evaporate spontaneously, a point will presently be reached at which the liquid is saturated with the solute. Crystallization will then begin and will proceed as the evaporation continues. The process of crystal formation in this case, however, is too low to be readily observed.

If a hot saturated solution of a crystallizable solid be allowed to cool, the solubility of the solute in most cases decreases more or less rapidly as the temperature falls, and the crystals may often be seen to form if the solution be carefully watched. Some experiments of this sort may be of interest.



CROWN PREPARED BY S. POLINSKY; PHOTO BY G. LEVY, BOTH OF ENGLISH HIGH SCHOOL

A. Fill a 50-cc. graduate full of hot water; this is simply to warm the graduate to avoid a sudden cooling effect later. In a clean flask heat 50 cc. of water to boiling and add a few grams of powdered lead iodide. Shake or stir well, keeping the liquid as hot as possible. Pour out the water in the graduate and filter the hot liquid in the flask into the graduate. Lead iodide is somewhat soluble in hot water so that the filtrate will contain some of the dissolved material. Now watch carefully. As the temperature gradually falls, bright spangles of lead iodide may be seen forming in the hot liquid and falling in a golden shower to the bottom of the graduate.

B. Dissolve 10 grams powdered oxalic acid in 25–30 cc. of hot water in a clean flask or beaker. Keep the liquid hot and neutralize with dilute ammonium hydroxide to slight excess of ammonia. Filter as hot as possible into a clean dry crystallizing dish; the filter funnel should first be warmed by pouring hot water through it. Now watch the filtered liquid. Beautiful white needles may be seen forming as the temperature falls until the whole is a mass of snow-white material.

C. Students who may wish to undertake something a little out of the ordinary in crystallization may be interested to try the following experiment. Cut a narrow band of tin from a small can not over three inches in diameter. Using this as a base, prepare a small crown by bending stout copper or iron wires into the necessary shape and fastening the ends to the

tin band. Tear some cotton cloth into narrow strips and wind the strips around the wire and band so that all of the metal is completely covered. Wet all of the cloth and suspend the crown so prepared in a solution of potassium dichromate till the cloth is well penetrated by the liquid, remove, and let dry; small crystals of the salt will form in the cloth to serve as "seed" for the later process. Prepare a *saturated* solution of potassium dichromate in 500 cc. water heated to about 80 degrees; the solution must be fully saturated at that temperature, and should be perfectly clear. Suspend the crown, top down, in the hot liquid and let it remain there over night. In the morning the crown will be found covered with bright red crystals following the lines of the wires and the band. Remove and let dry in a cool place. A lining of green velvet or other material may be made and a ribbon tied around the outside of the band. Nicely arranged in this way any student may well be proud of his work. Should the crystals become slightly dulled with the passage of time, they may be brightened by dipping them into acetic acid for a moment and then setting the crown in a cool place to dry.

"The Story of Nitrocellulose," a New Motion Picture. "The Story of Nitrocellulose" is the name of the latest motion picture produced by Hercules Powder Company, Wilmington, Del., for general distribution. The film, three reels in length, depicts the sources, manufacture, and uses of nitrocellulose, the versatile product which is the basis of modern lacquer, celluloid, and pyroxylin materials.

The early part of the film shows the source of the raw material—the cotton fields of the South—and shows the purification of the cellulose (cotton linters) at the Hercules plant near Hopewell, Va. The succeeding scenes of the Hercules plant at Gillespie, New Jersey, illustrate the nitration of cellulose and the purification and subsequent testing of the product.

Chemical and mechanical processes in the production of nitrocellulose are well illustrated by photographs and animated drawings. Chemical control to assure uniform high quality is an important element in the manufacturing process. The important part which nitrocellulose takes in present-day civilization is visualized by showing the diversified products of which it is an ingredient.

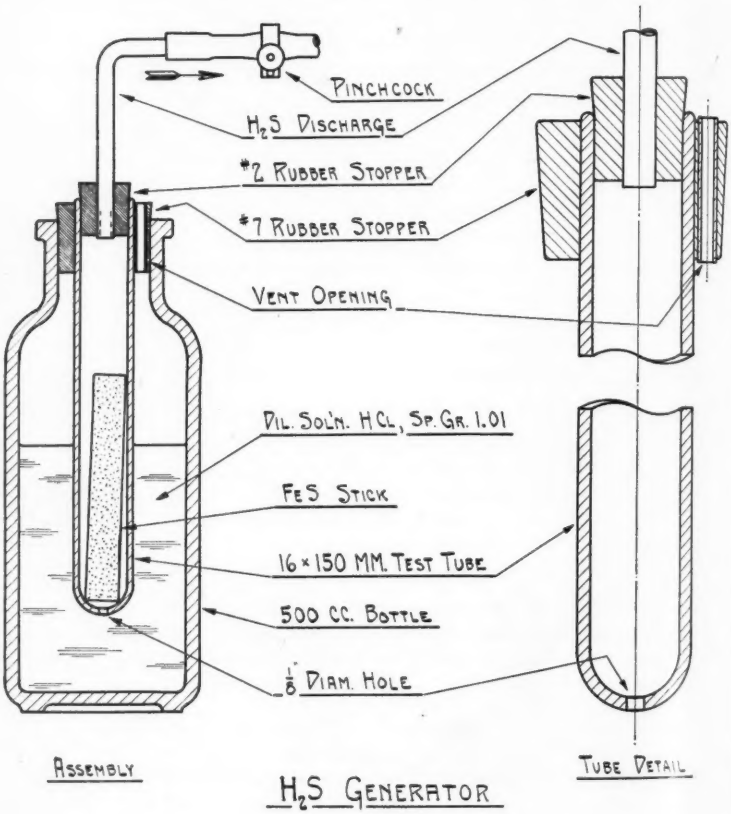
The film was made for Hercules by The Pathescope Company of America. "The Story of Nitrocellulose" is available in standard or small-size film by application to the Visual Education Department, Hercules Powder Company, Wilmington, Delaware.

Progress Exposition in 1933. A "Century of Progress Exposition" will be held in Chicago in 1933, and all countries are invited to participate. The exposition will picture all advances in progress which have been made in the last hundred years. The organization of the scientific section is in the hands of the United States National Research Council. Dr. A. D. Little, ex-president of the Society of Chemical Industry, is chairman of the sub-committee on chemistry, and Dr. C. G. Fink chairman of that on electrochemistry.—*Chem. Age*

A SIMPLIFIED HYDROGEN SULFIDE GENERATOR

NORVAL F. WILSON AND R. K. CARLETON, SHURTLEFF COLLEGE, ALTON, ILLINOIS

There appear from time to time in the literature descriptions of various forms of hydrogen sulfide generators designed for individual student use. In qualitative analysis classes of from fifteen to twenty students, the generator described herein has proved most satisfactory. It is extremely



H_2S GENERATOR

simple in construction and operation and any part if broken can be readily replaced. The use of ferrous sulfide in stick form and of very dilute hydrochloric acid overcomes difficulties often encountered in larger types of generators.

The construction and operation of the generator is briefly as follows. A bottle of 500 cc. capacity is provided with a No. 7 rubber stopper, through which pass two holes, one in the center, large enough to accommodate an ordinary size test tube, and

the other on the side, one-eighth inch in diameter. The latter serves as a vent to relieve back pressure. A one-eighth inch hole is blown in the bottom of the test tube, which contains a stick of iron sulfide. The bottle is filled slightly more than half-full of dilute hydrochloric acid, whose specific gravity is about 1.01. When the stopcock is opened, the acid is permitted to come in contact with the sulfide, producing thereby H_2S for any desired purpose, and on closing the stopcock, the back pressure created is sufficient to force the acid out of contact with the iron sulfide until more gas is required.

Because of its simple construction and its dependable operation, the generator lends itself admirably to individual use. [*Cf.* BARRUS, "A Convenient Form of Hydrogen Sulfide Generator," J. CHEM. EDUC., **5**, 1428 (Nov., 1928).]

New Borate Mineral Finding Commercial Use. Miners, prospectors, and mineralogists have so thoroughly searched every nook and cranny of the earth's upper crust that nowadays new minerals are seldom found or, where they are discovered, are apt to be rare and to exist in small quantities of no particular commercial importance. Nevertheless, a new boron-containing mineral, discovered within the last five years, has been found in such quantities as to render its commercial exploitation possible, according to the Pacific Experiment Station of the United States Bureau of Mines.

The new mineral, which has been variously called Razorite or Kernite, is found in the Mohave desert of California, at depths some 600 to 800 feet below the present surface of the ground. The pure mineral is colorless, transparent, and occurs in lamellar or columnar form. It contains the oxide of boron and of sodium, together with some water, and in places is of high purity, but differs markedly in physical properties from the ordinary borax of commerce. Chemists have not succeeded in preparing the new mineral form in the laboratory, for although it contains from 3.5 to 4 molecular proportions of water, it is dissolved in water only with considerable difficulty. It seems probable that the material is a product of volcanic activity.

Among other uses, the borate is employed in the manufacture of certain special glass and for glazes of sanitary ware.—*Ind. Eng. Chem., News Ed.*

Silver-Producing Mines of British Columbia. Native silver rarely occurs in British Columbia. Almost all of the metal produced in the Province is obtained from silver minerals associated with lead and zinc minerals or less frequently with copper or gold. Nearly every metalliferous mine contains some of the white metal but, with few exceptions, these mines are small and their commercial existence depends largely on their silver content.

British Columbia had in 1928 the record production of 10,600,000 ounces of silver, which is over 3 million ounces greater than that of Ontario, the next largest silver-producing Province. The production estimated for 1929 is only slightly less, being 10,400,000 ounces. The actual market value of this output is, however, considerably lower than that of the previous year, owing to the lower price of 53.1 cents as compared to 58.2 cents per ounce in 1928.

The largest silver producers in British Columbia are mines in which the silver content is low and the metal of only secondary importance, their high output being due to the large tonnage treated.—*Chem. News*

AN IMPROVISED POLARIMETER

C. C. KIPLINGER, STATE TEACHERS' COLLEGE, WEST LIBERTY, WEST VIRGINIA

That phase of organic chemistry called stereoisomerism is often approached by the teacher of organic chemistry in a small college with a degree of trepidation owing to the lack of equipment necessary for the proper illustration of this branch of the subject. A polarimeter of the usual type finds so little use in the small laboratory that the heavy initial cost is rarely justified by the limited service it renders.

The improvised instrument herewith described is amply adequate for demonstration purposes and will permit work being done of a semi-quantitative character. A small ring stand with a flat base is equipped with three small rings, *R*, *R*, *R*, as shown. On each of the lower two rings is placed a glass plate, *G*, *G*, to serve as stages, or supports, for the appropriate apparatus. *T* is a tripod microscope and *C* a glass cylinder or graduate with as plane a bottom as can be selected from those available.

P comprises the polarizer, consisting of two "piles" of glass plates (microscope slides serve well) the lower one coated with a black varnish, lampblack and shellac, or black sealing wax melted on. The first pile lies flat on the base, the second is supported contiguous to the first and at the optimum angle for polarization by a wedge of cork or wood, *K*. Bits of adhesive tape help to hold the plates in place. *L* indicates the course of the light and the double reflection gives the maximum degree of polarization. The writer has found that five plates in each pile are sufficient for the purpose in hand. One can also get excellent results with two plane black mirrors, if the light source is intense enough. Plates cut from thin negative or plate glass from any source, thoroughly cleaned, are as good as microscope slips.

The analyzer, *A*, consists of a small black mirror mounted with a bit of wax at the polarizing angle, about 55° from the horizontal, in a wedge-shaped recess cut in a small cork. This rests on a larger cork, *X*, so cut that it rotates easily in the supporting ring. A protractor, *D*, is attached to this same cork. The top of *X* and the analyzer should be painted a dull black.

Having assembled the instrument as shown in Figure 1, the observer looks down the vertical axis of the instrument by placing the eye at the point *A*, thus locating the illuminated field in the black mirror. The eye must be moved as the analyzer is rotated, so as to keep the field in view. The analyzer is adjusted with reference to the polarizer by rotating *X* until there is the maximum darkness in the field, using as the source of light a 100-watt frosted globe Mazda lamp. This may be intensified by means of a condenser, a 500-cc. flask filled with distilled water.

A cleavage piece of selenite, *S*, thin enough to show high interference colors (this can be split off from a large piece with a pen-knife) is placed beneath *T* and focused. The selenite is then rotated on its stage until the

maximum color effects appear between the "crossed" mirrors. The analyzer is now turned until the selenite shows a neutral grey tint. If a solution of cane sugar is now placed in the graduate, the colors will reappear to a certain extent, owing to the fact that the solution has rotated the plane of polarization, and it will be found necessary to turn the analyzer clockwise, that is, to the right, in order to restore the neutral grey. By centering the attention on a section of the selenite plate where red meets blue, the line of demarcation will be found to furnish a sensitive index to a relatively small angular change in rotation. By shading the lamp, wrapping the graduate or cylinder with electricians' tape and protecting the eye from extraneous light, measurements may be made that will correspond to within one degree.

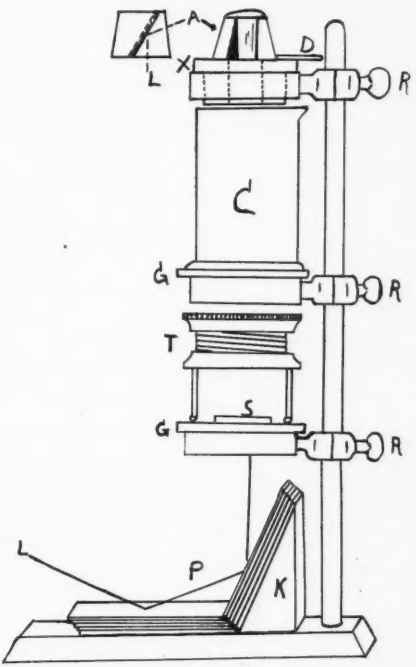


FIGURE 1

This type of polarizing equipment, also described in the literature (*1*) by the writer may be adapted to the ordinary compound microscope by moving the mirror aside and using the glass plates to reflect the light into the instrument, which must stand in the vertical position. A small cap analyzer as made above is set on top of the eyepiece. Or, if desired, the polarizer may consist of a blackened glass plate laid on the table immediately in front of the microscope and light reflected from it thrown into the axis of the instrument by a second reflection from the plane mirror with which the microscope is provided. The mirror will be at an angle approaching the vertical.

A test plate of selenite, or one prepared by allowing a solution of tartaric acid to crystallize on a slide, will aid in achieving the most efficient adjustment of the mirrors. If a drop of a solution of tartaric acid be allowed to crystallize on a slide and the forming of the crystals be observed between "crossed" mirrors, the phenomenon will be noted as unusually beautiful and impressive.

If the microscope is equipped with a condenser, interference figures formed by anisotropic crystals may be observed by mounting a Johannsen lens (*2*), a tiny glass sphere fused on a hair-like thread of glass, the sphere about 0.1 mm. in diameter, mounted as shown in Figure 2 on a split metal cylinder with a lug projecting downward, the cylinder fitting the objective and sliding up or down easily so as to permit the easy focusing of the spherical lens. The latter is held in place on the lug by means of wax, or a bit of adhesive tape. A 16 mm. objective furnishes ample power for this work. A fairly thick piece of mica will show a beautiful interference figure when the adjustment is correct. For good results it will be found necessary not only to focus the microscope, but also the Johannsen lens and the condenser as well. Chamot and Mason's book (*3*) gives both the theory and technic essential to a successful pursuance of studies in interference figures.

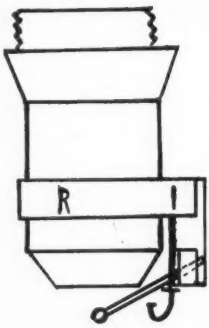


FIGURE 2

In lieu of a standard condenser, the writer has found that an ordinary water lens formed by blowing a thin bulb on a small glass tube, the sphere having a diameter of about 15 mm., cutting the tube to a length of about 2 cm., for a handle, filling with distilled water, and plugging the end, will give moderately good images. It may be attached to the underside of the stage with adhesive tape. Thin rings of cork are used to vary its distance from the stage opening.

A rotating stage graduated in degrees is essential for serious work in chemical microscopy. The writer believes that it is possible to construct an efficient chemical microscope along the lines suggested and at a cost much lower than at present available. The cap mirror analyzer can be used with eyepieces up to 10X without reducing the field to an unreasonable degree, if the mirror is sufficiently small in area. At any rate, many of the most beautiful phenomena of crystals reacting to polarized light may be enjoyed by any one who has a simple microscope and a bit of ingenuity.

Literature Cited

(*1*) KIPLINGER, *Sci. Am.*, **102**, 524 (1910).
(*2*) JOHANNSEN, "Manual of Petrographic Methods," 2nd edition, McGraw-Hill Book Co., Inc., New York City, 1918, p. 454.
(*3*) CHAMOT and MASON, "Handbook of Chemical Microscopy," vol. I, John Wiley & Sons, Inc., New York City, 1930, 470 pp.

A man's value in the world is estimated and paid for according to the ability he uses; not the ability he may possess.

THE CINCINNATI MEETING* OF THE A. C. S., SEPTEMBER 8TH TO 11TH

Program of the Division of Chemical Education

J. N. SWAN, *Chairman*
R. A. BAKER, *Secretary*
E. J. MORGAN, *Local Secretary*

MONDAY, SEPTEMBER 8TH

8:00 A.M.—*Breakfast Meeting, Executive Committee.* Dining room, Hotel Gibson.

TUESDAY, SEPTEMBER 9TH

1 2:00 P.M.—FOSTER D. SNELL AND BEATRICE S. FOX. "Glass versus Slate Blackboard."

2 2:20 P.M.—T. R. BALL. "A New Type of Electrically Heated Muffle Furnace."

3 2:35 P.M.—JOHN R. SAMPEY. "An Undergraduate Seminar."

4 3:00 P.M.—STUART R. BRINKLEY. "The Freshman Course in Chemistry for Students Who Have Had Secondary-School Chemistry."

5 3:30 P.M.—SAMUEL MORRIS AND ALVAH HEADLEE. "Lecture Experiments in General Chemistry."

WEDNESDAY, SEPTEMBER 10TH

8:30 A.M.—*Meeting of the Senate of Chemical Education.*

6 10:30 A.M.—SIDNEY S. NEGUS. "The Use of Homemade Talking Motion Pictures in the Writing of Chemical Formulas."

7 11:15 A.M.—LOUIS EHRENFELD. "Teaching Chemistry in Three Dimensions in the Museum of Science and Industry."

12:00 M. —*Luncheon, Division of Chemical Education.* Women's Building, University of Cincinnati. (Complimentary to high-school teachers of chemistry in the Cincinnati area.)

Symposium on the Qualifications of Chemistry Teachers

8 2:00 P.M.—BEN W. FRAZIER. "The Present Status of Teacher Training in the United States."

9 2:40 P.M.—WILHELM SEGERBLOM. "The Qualifications of Chemistry Teachers in Secondary Schools."

10 3:20 P.M.—NEIL E. GORDON. "The Qualifications of Chemistry Teachers in Colleges and Universities."

11 4:00 P.M.—B. S. HOPKINS. "The Training of Teachers in Service."

12 4:40 P.M.—A. J. CURRIER. "The Committee of the Division of Chemical Education on the Preparation of High-School Chemistry Teachers."

5:00 P.M.—*Meeting of Editors of the* JOURNAL OF CHEMICAL EDUCATION *and the Chemistry Leaflet,* Hotel Sinton.

6:00 P.M.—*Editors' Dinner,* Hotel Sinton.

THURSDAY, SEPTEMBER 11TH

13 9:00 A.M.—W. G. BOWERS AND C. A. FOSTER. "Examinations in Teaching Chemistry."

14 9:20 A.M.—WILLIAM O. SWAN. "A Method of Dispensing Qualitative Unknowns."

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* The preliminary program of the Cincinnati meeting appeared in the June 20th *News Edition* of *Industrial and Engineering Chemistry.* The final program appears in the August 20th number of the same publication.

15 9:30 A.M.—W. A. MANUEL. "Student Guidance. I. The Selection and Sequence of Courses Outside the Major Field."

16 9:50 A.M.—A. J. CURRIER. "The Sectioning Problem in General Chemistry."

17 10:10 A.M.—R. D. BILLINGER. "The Quantitative Trend in General Chemistry Laboratory Courses."

18 10:30 A.M.—ALYENE E. WESTALL AND L. F. AUDRIETH. "A Tonic for Run-Down Chemical Systems."

11:00 A.M.—*Business Meeting of the Division.* (Election of Officers.)

Complete Program: For reference to the complete program of the eightieth meeting of the American Chemical Society, of which the above is but a part, see the footnote at the bottom of page 2177.

Headquarters: Hotel Gibson has been selected as general headquarters, but most of the program meetings, including those of the Division of Chemical Education, will be held at the University of Cincinnati.

High-School Chemistry Teachers' Luncheon: On Wednesday, September 10th, through the courtesy of Mr. Wm. W. Buffum, the Division will be host at luncheon to all high-school teachers of chemistry in the Cincinnati area. These guests will also be invited to attend the symposium which follows on "The Qualifications of Chemistry Teachers."

Symposium Speakers: The following will participate in the symposium: DR. BEN W. FRAZIER, *Acting Chief*, Division of Collegiate and Professional Education, U. S. Department of Interior; DR. WILHELM SEGERBLOM, *Head of the Department of Chemistry*, Phillips Exeter Academy; DR. NEIL E. GORDON, *Editor* of the JOURNAL OF CHEMICAL EDUCATION and *Professor of Chemical Education* in The Johns Hopkins University; DR. B. S. HOPKINS, *Professor of Inorganic Chemistry* in the University of Illinois; PROFESSOR A. J. CURRIER, of the Department of Chemistry in Penn State College, and *Chairman* of the Division Committee on The Preparation of Chemistry Teachers.

Special Student Rates: The Society has voted to allow any regularly matriculated student, majoring in chemistry in any college or university, to register for the entire meeting for $3.00 instead of $8.00, which is charged non-member chemists. Sleeping accommodations at a nominal rate may also be secured by addressing the Local Secretary, Father E. J. Morgan, St. Xavier College, Cincinnati, provided arrangements are made in advance of August 16th.

Exhibits: Manufacturers of chemical apparatus and products, high-school and college laboratories, and other agencies which are interested in chemical education, are invited to send exhibits for the Atlanta Meeting. Free exhibition space will be reserved upon request to the Local Secretary, but each exhibitor must assume all costs of transportation and packing as well as responsibility for breakage and loss.

A prize of $1.00 is offered by the Division for the best exhibit prepared by a high-school chemistry class.

R. A. BAKER, *Secretary*

World Output of Synthetic Camphor. Dr. F. Bornemann, in the *Chemiker-Zeitung*, estimates the world output of synthetic camphor at about 23,000 kilos per day, of which about 18,000 kilos are manufactured in Germany, the remainder being produced in France, Switzerland, and Italy. The total utilization of both natural and synthetic camphor is distributed approximately as follows: 66 per cent to the celluloid industry, 14 per cent to the manufacture of disinfectants and similar products, 10 per cent to the pharmaceutical industry, and 10 per cent to the manufacture of explosives.—*Chem. Age*

Chemical Digest

THE AMERICAN UNIVERSITY LOOKS AHEAD

There is a movement in American Universities and in schools of specialized advanced study (such as medical schools, for a report has come from the Commission on Medical Education[1]) to individualize and vitalize instruction. The flaws in mass education are forcing themselves upon our notice, and there are definite attempts to overcome some of them. Modern interest centers on the exceptional student who, having been recognized as capable of more intensive and more independent study, can be separated from the group and given ample opportunity to develop to the utmost. The University of Wisconsin has mapped out an elaborate program.[2]

First Two Years—The solid front of inflexible freshman requirements will be broken. Between five and six hundred freshmen will be able to enter at once upon advanced work by virtue of having proved attainments that may not show on the bookkeeping record of their high-school grades.

Foreign Language—Ability to use language will take the place of hour requirements. It will not be a question of how many hours of language have been taken, but how far the student is able to use a language.

Two-Year Course—Those passing two years' work will receive a certificate and the rank of graduate in liberal studies. Not all who receive their certificates will necessarily be admitted to the junior year.

It is hoped that this will raise the standard of the first two years indirectly and possibly reduce the size of the university by reserving the university's opportunities for those who are willing to pay the price of hard work and who show genuine capacity.

Method—Several courses are recommended to be given in coöperation by several departments, which it is believed will give the student a better idea of the close relationship of his various studies. Good students, as they progress, will receive increasing freedom. The tutorial method of personal conference is definitely introduced with the hope of future expansion.

Graduation—General examinations will be required of all graduating to break down the present idea that all knowledge is divided into courses which, if once taken, may be forgotten. To graduate by piling up so many credits, without genuine mastery of subjects, will be more difficult. Exceptional students may speed up their work and take a master's degree at the end of four years.

The George Washington University has also mapped out such a plan.[3] It is called the Independent Study Plan and has the same underlying principle as that of the University of Wisconsin. Perhaps it stresses

[1] RAPPLEY, "Current Problems of Medical Education," *J. Am. Med. Assoc.*, **94**, 915–7 (Mar. 29, 1930).

[2] "Curriculum Revision at the University of Wisconsin," *Sch. & Soc.*, **31**, 561–2 (Apr. 26, 1930).

[3] "Independent Study Plan at the George Washington University," *Sch. & Soc.*, **32**, 14–5 (July 5, 1930).

more the relation between teacher and pupil. George Washington is also trying to make the last two years more specialized and more sharply separated from the first two, and this idea is being put into practice all over the country.

The idea is an excellent one. The university, however, is only a part of our educational system and the upper part at that. For such an advance to be beneficial, there must be a thorough reorganization of the whole system, from the primary grades up, such opportunities being offered at every stage, else the sudden throwing of a student on his own resources may prove disastrous. Also much good material may be wasted because of lack of earlier recognition and opportunity.

Mass education is insufficient not only in the case of the university, but in every branch and grade of education. To be sure, school boards are making a definite effort in this direction. More power to them!

M. W. G.

PROPAGANDA BY PUBLIC UTILITY CORPORATIONS*

This article on propaganda by public utility corporations is in effect a preliminary report prepared by the author at the request of the Association's Committee on Ethics and is approved by them. It contains four sections:

I. History, character, and purpose of the report.
II. What do the facts show?
III. Statement of the principle involved.
IV. Consideration of fundamental problems.

In the first section attention is called to the efforts of many upon both sides of the controversy to clear up the confusion and misunderstandings that are evident. The relationship of industry to the academic instructor needs clarification for the benefit of the public as well as of the industry and the professor. In this report, which is chiefly concerned with the teacher's side of the case, it is made very evident that the professor is to give thought to the duties and obligations of his position as well as its privileges. The facts when studied are said to justify the conclusion that "there has been much confusion in the public mind as to the various activities of the public utilities." This conclusion is illustrated.

The public, as well as some of the committees, has failed to distinguish between the various categories of academic instructors.

Very few cases are noted of alleged impropriety on the part of *regular* (over against some part-time subordinate) instructors in the academic departments.

* E. R. A. Seligman, *Bull. Am. Assoc. Univ. Profs.*, **16**, 349–68 (May, 1930).

As to the principle involved, it is well to get back to the original and real connotation of the term propaganda. This word came into disrepute during the war when governments sought to build national morale by spreading half-truths and sometimes absolute untruths under the guise of public information in regard to the real state of international affairs. Originally this term was practically synonymous with education. So used "propaganda in itself is entirely innocuous." The report proceeds:

> The fundamental principle, in any question of propaganda is that full, complete, entire and honest publicity—publicity as to the source, publicity as to the motives, publicity as to the objectives. In matters of possible importance for public policy, the principle is that of deserving and maintaining public confidence by a jealous observance of precautions against active bias or against occasioning the suspicion of bias.

Under the fourth section the report considers six problems. These are concerned with: conditions under which instructors may undertake outside employment; relation of such outside employment to the instructor's advice to public legislative or administrative bodies; method of remuneration for such employment; whether the technical scientist should presume to make public pronouncements in other fields such as that of economics; the propriety of educational institutions receiving donations or subventions from businesses or business associations and finally the propriety of the academic instructor accepting remuneration from a private source for the expression of opinion upon controversial questions of public policy.

In conclusion the author says,

> Great as are the rights of the university professor, far greater are his obligations to his associates, to the institution which he serves, to the public of which he is a part, and to the august and imperious mistress—science—of whom he is a humble representative and to whom he owes the most loyal and undivided fealty.

B. C. H.

BIBLIOCHRESIS: THE PILOT OF RESEARCH

BIBLIOCHRESIS, the scientific use of literature, has the pilotage of all scientific investigation. It has, in fact, the same relation to research as the latter has to management; it is the intelligence service of all orderly inquiry, the preparational agent of factual determination, the guide of experimental trial in eliminating chance, in the whole realm of science.

To be scientific, an investigation of any type must be made methodically—a condition that requires, primarily, that all scientific research be conducted in the light of recorded experience. This requirement applies to the exercise of the historical and analytic procedures of investigation as well as to the employment of the experimental method, whose use, whether for confirmation or for original work, rests upon prior knowledge and art, *i. e.*, accepted practice.

Bibliochresis, then, is the most indispensable tool in laying the foundation for scientific research. Since it enables the qualified worker to find the experience of his predecessors, as recorded in the literature, it confers upon him either the power to

predict the results of effort—this is the outcome if the recorded information is evidently factual, *i. e.*, definite and confirmed—or the ability to plan further research on the same or an analogous topic.

Thus Hamor and Bass* define bibliochresis and estimate its value to scientific research.

It has long been agreed by the scientific professions that an intimate knowledge of recorded experience in any given field is a prerequisite both to facilitating scientific decision and to projecting research. We quote:

Of the men best qualified to analyze the factors that lead to high scientific attainment—research directors, personnel managers, experienced investigators, technical editors, educators—few will deny the necessity of library studies as a discipline for the self-conceit of the researchful mind. The scientific societies and organizations and the philanthropic agencies for the advancement of science have been unanimous in recommending increased use of existing facilities and concerted effort to improve the technical libraries throughout the world.

Several facts confirm the opinion of these authorities concerning the value of bibliochretic work and opportunities.

(1) Bibliochresis occupies a prominent place in the curricula of research training schools. For example, a number of universities are now giving courses in chemical bibliography. Among the textbooks dealing with the subject wholly or in part should be mentioned "The Literature of Chemistry," by Crane and Patterson; "Chemical Publications," by Mellon, and "Introduction to Organic Research," by Reid. "Medical Bibliography" is another pedagogic innovation.

(2) There is a constantly increasing demand in industrial laboratories for chemical bibliographers, other scientific literary specialists and chemical economists.

(3) The recognition of the need for bibliographic material in compact form is shown by the demand for indexes to the literature, as evidenced by the large number of orders received by their publishers.

(4) Satisfactory incomes, considering everything, are enjoyed by a number of practicing bibliographers who specialize in preparing, for stipulated fees, select bibliographies and also reviews of the journal and patent literature.

(5) Many men have been found to be unsatisfactory in industrial research because of their lack of knowledge of elementary bibliochretic procedure. How often in our personnel work have we seen the criticism of a referee of a candidate to the effect that the latter "was not able to work with ease and interest in literature searches" or "was replaced by a better man because he could not be depended on to make a thorough survey of the literature."

(6) Systematic bibliochresis is the means of establishing authority and originality, in science as well as in history and jurisprudence.

One would not expect the character of library work appropriate for academic and that for industrial research to be identical. The authors point out differences as follows:

In the field of pure science, searching literature studies are made more or less as a matter of course. Such work is for the most part carried out in universities or research institutes with good bibliographic facilities and with somewhat more deliberate an

* HAMOR and BASS, *Science*, **71**, 375–8 (Apr. 11, 1930).

atmosphere than that in an industrial laboratory. There is usually a professor or research director to plan the investigation, which is generally for a thesis. The problem selected must be reasonably free from overlapping studies in order that the junior author may be assured of a research publication; he is supposed to publish a paper to fulfil all the requirements for his degree, or, at least, he is eager to be able to treasure reprints of an addition to his short list of papers. In either case, the disappointment aroused by finding that his efforts have been dissipated on something already worked out is not to be taken lightly by those who are training our youth for enthusiastic scientific careers. Then, too, his own efforts to make use of the library are not to be overlooked. An exhaustive bibliography is an essential part of his thesis (and it is to be regretted that more theses, with their extended bibliographic studies, are not available for general use). In his conversations with fellow students he incites them to destroy the historical background of his work. Finally, when the completed article is submitted to a journal, a board of editors jealously guards against the duplication of a previous publication. It must be remembered also that the literature pertinent to a problem in pure science is likely to be more easily located than in the case of an industrial project. In spite of all these precautions, unwitting duplication of results is not unknown.

The bibliographic problems of the industrial research man are much more complicated. He is expected to use his time to the best advantage. He must work in libraries that, as a rule, are not so thoroughly stocked as those of the universities, although this condition is being improved markedly. The literature of industrial science is more difficult to follow: the journals for both the technical and pure science publications must be examined; the patent literature must be much more carefully searched than in the case of pure science research; the publications of most interest to him will often contain veiled meanings, and finally, the things for which he is searching may have been done but never published. This last possibility is of the greatest importance in connection with supposedly patentable processes and products.

Yet we do find in both pure and applied research some scientists who are eminently successful, regardless of the fact that a systematic use of existing literature has been purposely avoided. These are the exceptions, however—the genius type, possessing great originality and resourcefulness, who would achieve fame in any field.

Few of us can attain to his heights. As time goes on and the various fields become more and more thoroughly worked over, genius will find it increasingly difficult to assert itself.

It seems to us that the attitude of mind of the man who can achieve continuous research success without using the literature systematically is susceptible to further analysis. He has a profound knowledge of his specialty and he keeps in touch with current progress, although in a desultory fashion. His self-confidence is maintained by his achievements as well as by his grasp of the field. He can therefore plan new work by visualization with reasonable accuracy. Self-satisfaction with his procedure comes to him through his success.

It is questionable, however, whether this attitude should be encouraged as a general practice. Today the scientist is an important factor in the economic life of a country and can best fulfil his duty to society by making continued progress instead of rediscovering old facts already recorded in literature.

There is one aspect of bibliochresis which is seldom emphasized:

In the hands of a specialist endowed with imagination, trends in research can be analyzed and forecasts can be made with a reasonable degree of probability. The worker can avoid fields in which from a survey of the literature, it appears that too many groups of workers are engaged to give promise of marked success if he starts in, far behind, to catch up with the others. On the other hand, a particularly keen man can sometimes perceive an important goal which the mass of workers have been too preoccupied to see.

The value to present-day scientific research of a critical study of the literature is again emphasized in the concluding paragraphs of this article.

Organization is characteristic of the age. All human activities are becoming more and more a matter of coördinated regulation. The dietetically chosen food we buy on a budget plan from a chain store has been systematically approved by city, state, and national health officers; it has been distributed, with or without intermediaries, to the retailer according to his calculated sales volume by the manufacturer, who has prepared its reception by scientifically executed advertising; it has been transported over railroads whose interrelations are controlled by governmental regulation based on economic reasoning; the raw materials were selected by means of standardized tests; even the ultimate producers are now being more and more firmly knit together by the economic necessity for management on scientific principles.

The same spirit of organization hovers over the research laboratory, which creates such products. The haphazard methods of the inventor will experience increasing difficulty in competing with organized research, both in pure and applied science. As the literature increases, more and more critical studies will be required, and still larger research units will be obliged to correlate their efforts to avoid duplication. It is not the time to urge less use of the library, but to encourage research workers to follow the literature as never before.

M. W. G.

THE BATTLE OF THE LABORATORIES

This article by Donald Wilhelm, appearing in a recent issue of *World's Work*,* centers about the important work done by Arthur D. Little, Inc., Cambridge, Massachusetts, as an example of the position occupied by chemical research laboratories in the manufacturing work. To quote:

In most manufacturing industries and in many others, competition has become a battle between the laboratories—a battle behind which we find mass financing, mass production, mass advertising, mass merchandising—a battle in which quarter is neither asked nor given, in which, with all things reasonably equal, the manufacturer with the best laboratories wins.....

Today Science has made manufacturing into an art! So, about the time a manufacturer thinks that he has got himself all the way up the ladder of success and pulled the ladder up after him while thanking his lucky stars that he has an exclusive source of materials, some fellow across the street or in another country indicates that his

* Wilhelm, *World's Work* June, 1930.

industrial laboratories have produced—almost as mysteriously as a magician produces a rabbit out of the old silk hat—a synthetic material that is better yet!....

And today, just about the moment a manufacturer in high glee hugs himself for his originality in producing a new process or a new machine or any other competitive advantage, some inconsiderate laboratory somewhere produces a process or a machine that is so much better that the stockholders of the less fortunate manufacturer see him so soon done for they wonder "what he begun for."....

Nearly all of the thousands of industrial laboratories in America are merely plant and production control laboratories.....

Whereas we once talked of the chemical industries as something apart from industry in general, *all* industry is now rapidly being chemicalized.

It is an interesting article and fairly well written. Those who have little conception of the part chemistry is playing in modern civilization would do well to read it.

C. E. M.

Animal Charcoal. Bones collected from the packing industry now figure directly in at least three important fields of manufacture: fertilizers, animal glue, and bone black or animal charcoal. Owing to its physical structure, bone black has a strong affinity for organic coloring matter and thus has been used as a decolorizing and clarifying agent in the manufacture of many products, especially vegetable oils, fruit juices, glucose, and sugar, the last two taking the bulk of the product.

Bone black is made by the destructive distillation of bone, practically all of the organic matter being driven off, leaving a very hard and porous calcium phosphate skeleton covered with 9 to 12% of active carbon which affords an extremely large absorbing surface. The volatile matter is cooled and washed with water to recover ammonia, and the bone tar is generally cooked down to bone pitch, though there is some outlet for it in special paints or coatings. Because of its nitrogen value, the distillate from the pitch still, bone oil, is sometimes used for fertilizers but more often it is burned under the retorts. It is understood that bone pitch has some merit as an electrical insulating material, though its odor precludes wide industrial use at present.

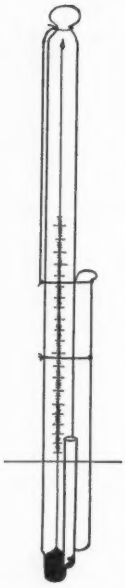
In recent years there has been a tendency in the vegetable oil and fruit juice industries to supplant bone black by infusorial earths or vegetable decolorizing carbons.

In the early days of bone black manufacture it was possible to choose carefully the bones used. Now, however, the supply has become limited and the better bones are being taken by other industries, thus leaving to the bone black manufacturer poorer material at a higher price, with the result that competition with other decolorizing agents has been made increasingly difficult. However, the probability of any immediate change by the glucose and sugar industry is slight, due in part to the prohibitive cost of remodeling the plant and partly to improvements in methods of manufacturing and revivifying the black whereby the ultimate costs have been materially reduced. It is also understood that new sugar houses are being designed to use bone black. It is probable that some trade now lost to the bone black maker may eventually be regained as a result of improvements in manufacturing and revivifying methods.

Comparatively little time has been given in the past to the study of bone tar, but the interest in synthetic resins and plastics, combined with the improvements in condensation, washing, and distillation equipment, developed by the oil industry indicate that a careful study of this material may yield products of considerable value.—*Ind. Bull., Arthur D. Little, Inc.*

ABSTRACTS

APPARATUS, LABORATORY PRACTICE, AND DEMONSTRATIONS



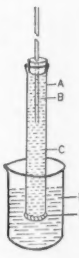
Device for Fastening Melting-Point Tubes to Thermometers. H. L. LOCHTE. *Ind. Eng. Chem., Analyt. Ed.*, **22,** 200 (Apr., 1930).—A simple and effective means of preventing the slip of melting-point tubes is shown in the diagram. A glass rod three to five mm. in diameter is fastened to the thermometer. Even the most vigorous stirring will not cause the melting-point tube to loosen when placed as shown in the sulfuric acid bath. When used with a Thiele m.-p. apparatus the rod may be fastened with a wire, or passed through a single elongated hole in the cork along with the thermometer. D. C. L.

Support for Melting-Point Tubes. E. V. ZAPPI. *Rev. facultad cienc. quím.* (*Univ. La Plata*), **6,** Pt. I, 77–8 (1929); *Chem. Abstr.*, **24,** 2331 (May 20, 1930).—A gold or platinum strip is curved to encircle the thermometer bulb and is then sheared in such a manner as to form a clip which holds the melting-point tube. C. E. M.

Glass Tube Cutter. M. KNOPFF. *Brennerei-Ztg.*, **47,** 16 (1930); *Chem. Abstr.*, **24,** 2331 (May 20, 1930).—A diamond mounted on a special attachment for easy manipulation is recommended. C. E. M.

The Florence Flask. See this title on page 2194.

Bending Glass Tubing. R. N. ALLEN. *Philippine J. Sci.*, **38,** 399 (1929); *Chem. Abstr.*, **24,** 1547 (April 10, 1930).—Asbestos fiber is tamped tightly into the bore of the tube where desired bend is to be made; the glass may then be heated and bent without any collapse occurring. The fiber may be removed when cool with a piece of wire, as it does not fuse into the glass. C. E. M.



An Osmometer with a Gelatin Membrane. H. BOUYGUES. *Bul. soc. bot.* (France), **76,** 90–1 (1929); *Chem. Abstr.*, **24,** 2331 (May 20, 1930).—Glass tubes *A* and *B* are 7 × 0.8 cm. and 100 × 0.15 cm. (inside diam.), respectively. If solution *C* is more concentrated than solution *E*, water will flow through the gelatin membrane *D* into tube *A*, causing a rise of liquid in tube *B*. Membrane *D* is applied by dipping the lower (ground edge) end of tube *A* into a 5–10% solution of gelatin of depth in a watch crystal that corresponds to the membrane thickness desired. The semi-permeable characteristics of the membrane may be altered by varying the thickness or the water content, or by using another substance. C. E. M.

Apparatus for the Continuous and Automatic Purification of Mercury. J. CARBIÈRE. *Bull. soc. chim.*, **47,** 331–2(1930); *Chem. Abstr.*, **24,** 2919 (June 20, 1930).—A combination of the Botolfsen (*Chem. Abstr.*, **24,** 2) apparatus with the Gorey apparatus so that the Hg is distilled after passing through the acid wash. C. E. M.

Prevention of Overtitration. H. H. CUSTIS. *Chem. Analyst*, **59,** 18 (Mar., 1930).—A damaged 5-cc. pipet is broken off at the bulb, and the opening partially closed by heating in the flame. The bulb is placed in the solution to be titrated. The size of the opening is so regulated that diffusion into the main body of the liquid is slow, but it will readily be drained when raised above the liquid. D. C. L.

Renovation of Illegible Thermometers. E. A. VUILLEUMIER. *Chem. Analyst*, **19,** 18 (May, 1930).—Many thermometers that have been in use for some time become almost illegible. A number of lumber crayons were tried out. Dixon's No. 494 Carbon Black Lumber Crayon was found to be excellent. The markings are applied by rubbing the crayon over the etched lines. The finished product is only slightly inferior to the new article in appearance, and superior in wearing quality. D. C. L.

A Study of the Various Methods for the Separation and Estimation of Nickel and Cobalt Salts. G. GERMUTH. *Chem. Analyst*, **19,** 4–10 (Mar., 1930).—These investigations were carried out by the Bureau of Standards at Baltimore, Md. Solutions containing known amounts of Ni and Co in varying proportions were analyzed by several well-known methods to find which was most suitable under each condition. Certain extraneous ions were added to ascertain the accuracy of the method in the presence of ions frequently associated with Ni and Co. The conclusions in brief are: (1) the alpha benzildioxime method of determining Ni in the presence of Co and other ions is most accurate when applied to small amounts of Ni. (2) The dimethylglyoxime

method is most favorable if the amount of Co is less than 0.1 gm. (3) Determination of Co by KNO_2 is not recommended for routine analysis, due to time consumed and creeping of precipitate on filter. (4) Nitroso-beta-naphthol method should be used when the proportion of Co is much smaller than that of Ni. D. C. L.

Makeshifts. D. S. DAVIS. *Chem. Analyst*, **19**, 15 (Mar., 1930).—Makeshifts are often important in field work, or if the supply of reagents is incomplete. If phenolphthalein is lacking, a satisfactory indicator may be prepared by shaking rubbing alcohol with Nut-lax, Feenamint, or Phenolax. An electric toaster may serve as a drier. Canadian readers will find that the liter mark on their quart milk bottle falls in the narrow portion of the neck about an inch and one-half from the top. D. C. L.

The Determination of Total Sulfur in Rubber. J. G. MACKAY. *Chem. & Ind.*, **49**, 233T–241T (May 23, 1930).—A review of the previous work and the literature dealing with this subject. A new method involving the oxidation by means of nitric and perchloric acids and bromine followed by volumetric determination as benzidine sulfate of the sulfuric acid produced. E. R. W.

The Detection and Determination of Small Quantities of Chlorine in Flour. D. W. KENT-JONES AND C. W. HERD. *Chem. & Ind.*, **49**, 223T–226T (May 16, 1930).—A review of the methods of determining the small amount of chlorine present in flour which has been bleached by chlorine treatment. An explanation is offered for the differences obtained by the Volhard and chromate processes. A suggested procedure is outlined in detail. E. R. W.

High-Frequency Equipment for Biological Experimentation. J. G. MCKINLEY, JR., AND G. M. MCKINLEY. *Science*, **71**, 508–10 (May 16, 1930).—Detailed directions are given for constructing out of standard parts an apparatus capable of applying electrical fields of from 150,000,000 to 50,000,000 cycles per second to animals varying in size from large rats to small insects. G. H. W.

Reducing Moisture Evaporation from Petri Dish Cultures. E. E. HUBERT AND T. H. HARRIS. *Science*, **71**, 510–1 (May 16, 1930).—The method described "consists in the application of a wide rubber band to the periphery of the dish so that it covers the opening between the two parts and overlaps on the bottom and top sufficiently to prevent slipping off." The bands were especially made by A. W. Faber. G. H. W.

Use of Microscope. See **The Fourth Degree** directly below.

The Fourth Degree. G. R. SALISBURY. *Educ. Focus*, May, **1930**, p. 8.—The police often give the suspected criminal "the third degree." The author in this article proposes the use of the microscope in giving "the fourth degree." The microscope may be used in the examination of the following types of materials: blood and other stains; their identification, classification, and age may be determined; ballistics having to do with firearms, type, caliber, bullet structure, shells, and firing pins; messages related to handwriting, type faces, codes, and typewriting; miscellaneous, including knives, fabrics, chemicals, and finger prints. The paper goes into some detail in showing how the microscope could identify human in contrast with the blood and hair of other animals. A very striking illustration of forgery writing is described, aided by illustrations.

The editor's note promised the reader, who is interested, with reference material or its source in response to a request for the same. B. C. H.

Some Scientific Instrument Makers of the Eighteenth Century. See this title on page 2193.

TEACHING OBJECTIVES, METHODS, AND SUGGESTIONS

Some Light on Visual Instruction. G. STRAUBENMULLER. *Sch. Exec. Mag.*, **49**, 409 (May, 1930).—In giving visual instruction we must not confine our efforts to the presentation of objects, processes, occurrences, models, or pictures, but must teach the observer how to see and how to form clear mental images.

As means of visual instruction there may be used the illustrated book, stereoscope, magic lantern, stereoptican, projection lantern, and moving picture. Special advantages of the moving picture are: it enables close study of process too quick or too slow for human perception; it wrests from nature some of her long hidden secrets; it shows manipulations as in surgical operations rarely seen otherwise.

However, we must guard against fake pictures; fostering of mental laziness; the idea that the picture will take the place of study and experimentation; the notion we are mastering scientific principles when we look at scientific pictures. J. W. H.

ADMINISTRATIVE PROBLEMS AND DEVICES; CURRICULA

Curriculum Revision at the University of Wisconsin. ANON. *Sch. & Soc.*, 31, 561–2 (April 26, 1930).—See digest on **The American University Looks Ahead** on pages 2179–80. K. S. H.

Independent Study Plan at the George Washington University. ANON. *Sch. & Soc.*, 32, 14–5 (July 5, 1930).—See digest on **The American University Looks Ahead** on pages 2179–80. K. S. H.

School of Criminal Investigation at the University of Chicago. See **The Chemist as a Detective** on page 2188.

Current Problems of Medical Education. W. C. RAPPLEYE. *J. Am. Med. Assoc.*, 94, 915–7 (Mar. 29, 1930).—See digest on **The American University Looks Ahead** on pages 2179–80. C. E. M.

KEEPING UP WITH CHEMISTRY

The Chemist as a Detective. C. H. LA WALL. *Am. J. Pharm.*, 102, 297–318 (June, 1930).—*Popular science talk of the Philadelphia College of Pharmacy and Science.* An article concerning the chemists who are called upon to support some phase of the law and to cope with the many phases of science which have to do with the detection and punishment of crime. The article covers a large field to prove that the chemist may well be classed as a detective in connection with law enforcement. He must be able to detect violations of the food adulteration laws, false or fraudulent documents and letters, counterfeit banknotes and spurious coins; he must be able to recognize and identify blood stains, water contamination, textile fibers, etc.; he must have a knowledge of explosives and their composition; he must be familiar with the chemistry of narcotics and cosmetics. Due to the "toxicomaniacs" of today, his time is pretty well occupied with toxicological cases. There is more widespread recognition of the detective chemist in European countries than here in America. Courses in criminalistics have been given in the Universities of Prague, Bucharest, Lausanne, Liège, and other prominent European institutions. In America Chief of Police Vollmer of Berkeley, California, has made an international reputation for the systematic and continuous use of scientific methods in the detection of crime. The U. of Chicago is now conducting a course with Mr. Vollmer, a department which is called the "School of Criminal Investigation." G. O.

The Battle of the Laboratories. D. WILHELM. *World's Work*, June, 1930.—See digest under this title on pages 2184–5. C. E. M.

Photography Identifies Gems by Their Flaws. F. HEITZLER. *Sci. Am.*, 143, 94–5 (Aug., 1930).—Flaws in gems are classified and method of detecting them described. Illustrations are included of both gems and equipment. C. E. M.

Acrolein a Warning Agent in Refrigeration. *Ind. Eng. Chem.*, 22, 684 (June, 1930).—Acrolein gives a distinct odor in one part per million of air, and is intolerable when present in three to five parts per million. Its use with methyl chloride may solve the problem of leakage in methyl chloride refrigerating systems. Enough acrolein is added to make non-injurious concentrations of methyl chloride detectable and immediately injurious concentrations intolerable, compelling persons to leave. Acrolein seems to be the most suitable warning agent of the substances thus far investigated. D. C. L.

Philippine Camphor. A. P. WEST AND H. TAGUIBAO. *Philippine J. Sci.*, 42 (Feb., 1930).—The authors give the result of the examination of young trees of the laurel camphor, *Cinnamomum camphora*, which have been planted by the Philippine Bureau of Forestry since 1910 with seeds obtained from Japan. In Formosa and Japan the bulk of the crystalline camphor is obtained by a crude process of distillation from the wet wood of old trees, the leaves containing mainly camphor oil. In these young trees in the Philippines, very little camphor was found in the wood, but the leaves yielded 2–7 per cent on the dry weight. The authors point out that some of the trees examined contained practically no crystalline camphor in the leaves, but these trees yielded a levo-rotatory camphor oil distinct from the camphor oil of commerce, which is dextro-rotatory and occurs along with the crystalline camphor. The authors discuss the possibility of obtaining supplies of camphor from the Philippine trees able to compete with the synthetic product made from the pine tree turpentine, which contains usually about 70 per cent pinene. They point out also that the Philippine pines (*Pinus insularis*) may be a valuable source of this synthetic competitor, as they appear to yield a turpentine rich in pinene. C. E. M.

Certified Food Colors: Their Characteristics and Tests. M. C. GALLAGHER AND S. E. OWEN. *Am. J. Pharm.*, 102, 329–37 (June, 1930).—A review of the history of

food colors, their use and the laws governing them; a list of the dyes approved by the U. S. Dept. of Agriculture with their chemical composition, physical properties, and color reactions with both acids and alkalies. G. O.

The **Problem of Saline Drinking Waters.** I. S. ALLISON. *Science*, **71**, 559–60 (May 30, 1930).—Saline drinking waters high in sulfate from northwestern Minnesota were found to be responsible for poor condition of cattle in those regions. Details of composition of the waters are given. G. H. W.

Please **Pass the Salt.** L. BENEDICT. *Pract. Home Econ.*, **8**, 142 (May, 1930).—Salt is one of those familiar things, the presence of which is accepted as a matter of course. But it has a number of vitally important functions in the body. It is essential to the formation of the gastric juice. The average person requires about 12 lb. of salt a year. Only about half of this comes in the raw prepared foods we buy. There is an additional consumption of about 64 lb. per capita for various purposes as ice cream freezing, food preserving, water softening, cheese and butter manufacturing, and chemical and dye uses.

Salt has been one of nature's gifts most prized by man. It has been used in sacrifices; as a tie of friendship; as money or a means of exchange. Its possession has led to wars as well as forwarded peaceful pursuits.

Its sources and methods of purification are described. J. W. H.

Iodized Salt—A Food or a Drug? D. W. HORN. *Am. J. Pharm.*, **102**, 242–53 (May, 1930)—Salt is said to be the second most important food (water being first). In "iodized salt" the salt is merely a vehicle to convey iodides to the consumer. It is commonly known that iodine is used for treatment of goiter. But the American Medical Association advocates definite dosage with iodine-bearing products rather than the indiscriminate use of iodized salt of varying composition. (See abstract **Iodine—The Element of Doubt** on page 1697 of the July, 1930, J. CHEM. EDUC.) G. O.

Modern Boiler Development and Feed Water Treatment. W. S. COATES. *Chem. & Ind.*, **49**, 221T–222T (May 9, 1930); 230T–232T (May 16, 1930); 241T–244T (May 23, 1930).—A rather extensive discussion of various water softening and conditioning processes, including lime-soda, zealite, Neckar, and trisodium phosphate treatments. A bibliography is included. E. R. W.

Water Softening. See **Modern Boiler Developments and Feed Water Treatment** immediately above.

Chandler Lecture, 1929. Electrochemical Interactions of Tungsten, Thorium, Cesium, and Oxygen. See this title on page 2196.

Adhesives. ANON. *Silicate P's & Q's*, **10** (June, 1930).—"A man may adhere to a political party, a wife, or an error without any intermediate agency, but when things adhere some medium is usually implied to cause the union." The considerations which affect the choice of adhesives for a particular use are many, such as: strength, permanence, cost, odor, speed, stiffness, ease of application, and in some cases ease of removal.

Fiber-shipping containers should be so well sealed that they cannot be pilfered without destruction of the container. Some factors entering into securing a good seal with silicate are: removal of the necessary amount of water to enable the silicate to set and acquire a given strength, the thickness of the film of adhesive used, and the nature of the surfaces to be sealed. The water taken from the adhesive is removed by the paper. The use of pressure on the surfaces is advisable. H. T. B.

The **Detection and Determination of Small Quantities of Chlorine in Flour.** See this title on page 2190.

The **Determination of Total Sulfur in Rubber.** See this title on page 2190.

Solvents and Swelling Agents for Organophilic Colloids. W. B. LEE. *Chem. & Ind.*, 49, 226T–229T (May 16, 1930).—Raw rubber and cellulose esters swell and disperse in certain organic liquids. A table is given showing the relative tendency of raw rubber, cellulose acetate, and celluloid to swell or disperse in 75 different organic liquids. In general, solvents or swelling agents for raw rubber are non-solvents or non-swelling agents for cellulose acetate and celluloid. Methyl and ethyl benzoates are noteworthy, being solvents for both cellulose acetate and raw rubber, and strong swelling agents for celluloid. E. R. W.

Dyes and Their Application: Recent Technical Progress. L. J. HOOLEY. *Chem. Age, Dyestuffs Mo. Suppl.*, **22**, 31–2 (May 10, 1930).—A brief discussion of some recent basic dyes and methods of application. E. R. W.

Basic Intermediates for Dyestuffs: No. 34—The Naphthol Sulfonic Acids—(2). *Chem. Age, Dyestuffs Mo. Suppl.*, **22**, 30–1 (May 10, 1930).—An outline of a method of manufacture of 2-naphthol-1-sulfonic acid and B-naphthol disulfonic acids. E. R. W.

The Effect of Sulfuric Acid Treatment on the Germination of Sugar Beet Seed. F. HANLEY AND R. M. WOODMAN. *Chem. & Ind.*, **49**, 216T–220T (May 9, 1930).—Experiments seem to indicate that germination of sugar beet seed is improved by treatment of the seed with approximately 80% sulfuric acid. E. R. W.

Chemical Warfare. W. J. MORONEY. *Chem. Warfare*, **16**, 752–6 (May, 1930).—The gas mask offers the surest protection against lung irritants and poisons yet devised but much training is required before it can be used most effectively. A workable and efficient method of impregnating cloth with chemicals which will react with war gases has been evolved. E. R. W.

Some Applications of the Electronic Theory of Valency. See this title on page 2190.

The Meaning of the Crystal. See this title on page 2191.

Recent Advances in Science: Physical Chemistry. See this title on page 2191.

Recent Advances in Science: Physics. See this title on page 2191.

Recent Progress in Atomic Physics. See this title on page 2191.

A Contribution to the Undulatory Theory of Matter and Quantum Theory of Light. See this title on page 2191.

SCIENTIFIC REVIEWS AND BIBLIOGRAPHIES

The Detection and Determination of Small Quantities of Chlorine in Flour. Includes review of previous work. See this title on page 2189.

The Determination of Total Sulfur in Rubber. Includes review of previous work. See this title on page 2189.

Certified Food Colors: Their Characteristics and Colors. Review of subject. See this title on page 2188.

Cesium, Rubidium, and Lithium. R. M. SANTMYERS. *Chem. Age, Mo. Met. Sec.*, **22**, 27–8 (May 3, 1930).—A review of the physical and chemical properties, occurrence, specific tests, and uses of the alkali metals, especially cesium, rubidium, and lithium. E. R. W.

Mechanism of Carbohydrate Oxidation. W. L. EVANS. *Chem. Reviews*, **6**, 281–315 (1929); *Chem. Abstr.*, **24**, 831 (Feb. 20, 1930).—E. presents a picture of the oxidation of carbohydrates from the simplest mols. to the sugar mols. Most of the conclusions are based on exptl. results previously published by him. In the alk. oxidation of EtOH the critical equil. is between α-hydroxyethylidene, AcH and CH_2:CHOH; in iso-PrOH solns. it lies between isopropylidene, acetone, and isoacetone; in the hexose sugars the equilibrated mixt. consists of the isomeric hexoses studied by de Bruyn and van Ekenstein (*Rec. trav. chim.*, **1895–1908**) and the several enediolic hexose isomers postulated by Nef (*Ann.*, **1904–14**) and their ultimate fission products. These equilibrated systems are markedly disturbed by the magnitude of the alkali concn. and the temp. When these alk. systems are studied in the absence of an oxidizing agent it is possible to prove experimentally the effect produced by varying alkali concn. In the α-hydroxyethylidene–AcH–CH_2:CHOH system the formation of Ch_2:CHOH is a linear function of the alkali concn.; in the acetone–isoacetone system, the concn. of the isoacetone is a logarithmic function of the base used. In alk. solns. of the hexose sugars and in the disaccharide maltose, the amounts of lactic acid, AcCHO, HCO_2H, and AcOH formed are definite functions of the alkali used. The same relationship also holds for the two trioses, glyceric aldehyde, and $CO_2(CHOH)_2$. In the oxidation of glucose, fructose, and galactose in CuOAc solns., it is possible to trace the reaction mechanism if one assumes an equilibrated condition of certain enediolic forms of the hexose as well as of the hexosone. The tendency of the increased H-ion concn. is to suppress the progress of the oxidation. C. E. M.

Extended Theory of Acids and Bases. T. M. LOWRY. *Trans. Faraday Soc.*, **26**, 45–6 (1930); *Chem. Abstr.*, **24**, 1553 (April 10, 1930).—A claim to priority on an extended theory of acids and bases in catalysis over that of Brønsted as set forth in *Chem. Abstr.*, **17**, 3821, and mentioned in *Ibid.*, **23**, 1338. The original paper of L. is abstracted in *Chem. Abstr.*, **17**, 2818. Bases are defined as acceptors of H nuclei. The term "proton" is discussed. C. E. M.

The Principles of the Electronic Theory of Valency. R. COLLOMB AND J. MARTINET. *Rev. gén. sci.*, **40**, 241–5 (1929); *Chem. Abstr.*, **24**, 2371 (May 20, 1930).—A short review in simple terms. C. E. M.

Some Applications of the Electronic Theory of Valency. R. COLLOMB AND J. MARTINET. *Rev. gén. sci.*, **40**, 261–5(1929); *Chem. Abstr.*, **24**, 2371 (May 20, 1930).—A semi-popular review. C. E. M.

The Doctrine of Atomic Valency. *Nature* (London), **125**, 807–10 (May 31, 1930).—This is a review by Henry E. Armstrong of Richard Anschutz's life of August Kekulé.

This is much more than a review and is rather a record of the growth of this doctine by almost the only man living who was acquainted with the chief actors, Kekulé, Frankland, Kolbe, and A. W. Hoffmann. Kolbe, Armstrong says, "was the best chemist of them all."

It is a most interesting personal narrative and very well worth reading. F. B. D.

The **Meaning of the Crystal.** W. H. BRAGG. *Science*, **71**, 547–50 (May 30, 1930).—*Medal Day address, delivered at the Franklin Institute, Philadelphia, Pa., on May 21st.* A short and simple exposition of modern crystal structure theory. G. H. W.

Modern Corpuscular Theory of Matter before John Dalton. See **The Honorable Robert Boyle: A Chapter in the Philosophy of Science** on page 2194.

Newton: The Emission Theory of Light and Chemical Doctrine in the Eighteenth Century. See this title on page 2194.

Newton and the Exposition of Chemical Doctrine in the Eighteenth Century. See this title on page 2194.

Recent Advances in Science: Physical Chemistry. R. K. SCHOFIELD. *Sci. Progr.*, **24**, 572–8 (Apr., 1930).—A review of recent work on molecular spectra. C. E. M.

Chemical Forces, the Constitution of the Atom and Refractometric Data. K. FAJANS. *Anales soc. españ. fís. quím.*, **28**, 22–46 (1930); *Chem. Abstr.*, **24**, 2665 (June 10, 1930).—A general survey is given of F.'s studies of the refraction of free gaseous ions. C. E. M.

Recent Advances in Science: Physics. L. F. BATES. *Sci. Progr.* **24**, 381–9 (Jan., 1930).—Review of recent work on ortho- and para-hydrogen, and on the Raman effect. C. E. M.

Recent Advances in Science: Physics. L. F. BATES. *Sci. Progr.*, **24**, 565–72 (April, 1930).—A review devoted chiefly to the relation between matter and radiation, and supraconductivity. C. E. M.

Recent Progress in Atomic Physics. L. G. CARPENTER. *World Power*, **13**, 244–9 (1930); *Chem. Abstr.*, **24**, 2370 (May 20, 1930). C. E. M.

The Trend of Modern Physics. A. EINSTEIN. See **Professor Einstein's Address at the University of Nottingham** on page 2196. M. W. G.

Waves and Corpuscles in Modern Physics. L. DE BROGLIE. *Rev. gén. sci.*, **41**, 101–8 (1930); *Chem. Abstr.*, **24**, 2665 (June 10, 1930).—*Nobel prize award speech.* A review of the atomic theory and electrical theory of matter and the wave theory of light leading to the modern conception of matter composed of waves and of corpuscles. C. E. M.

A Contribution to the Undulatory Theory of Matter and Quantum Theory of Light. MOHOROVIČIĆ. *Arhiv. hem. farm.*, **3**, 141–64(164–8 German) (1929); *Chem. Abstr.*, **24**, 2371 (May 20, 1930).—A very simple and clear description of de Broglie's theory and of a new wave theory of matter is given. C. E. M.

Symmetry of Time in Physics. G. N. LEWIS. *Science*, **71**, 569 (June 6, 1930).—*Address given on the occasion of the presentation of the gold medal of the Society of Arts and Sciences, New York, April 17, 1930.* G. H. W.

Research Work in Germany from 1920–27. See this title on page 2197.

HISTORICAL AND BIOGRAPHICAL

Richard Willstätter. (*1*) *Les Prix Nobel en 1914–18.* P. A. NORSTEDT AND SÖNER, Stockholm, Sweden, **1920**, pp. 49–53, 110–1.—Contains a brief outline of work for which Nobel award was made, brief biographical notes, summary of researches, and portrait. (*2*) **Scientific Worthies. XLV. Richard Willstätter.** H. E. ARMSTRONG. *Nature*, **120**, 1–5 (1927).—Biographical note with portrait and a brief account of Willstätter's work on chlorophyll and plant-coloring matter. (*3*) **Greater Safety from New Anesthetic.** *Science News Letter*, **18**, 19 (July 12, 1930).—Short note on new anesthetic used in eye surgery developed by Willstätter and Duisberg. (*4*) **Problems and Methods in Enzyme Research.** R. WILLSTÄTTER. *J. Chem. Soc.*, **1927**, 1359–81.—The Faraday lecture for 1927. M. W. G.

Svante Arrhenius. E. H. RIESENFELD. *Ber.*, **63A**, 1–40 (1930).—Biography with portrait. C. E. M.

F. W. Aston. See **Cambridge University** in **Local Activities** on page 2208. M. W. G.

Jöns Jacob Berzelius and His Relation to Humphry Davy. B. DUSCHNITZ. *Kali*, **23**, 326–9, 344–8 (1929); *Chem. Abstr.*, **24**, 760 (Feb. 20, 1930). C. E. M.

Sir William Bragg. See **Cornell University, Royal Institution of Great Britain, London,** in **Local Activities** on pages 2204 and 2208, respectively. M. W. G.

Bohuslav Brauner. *Collection Czechoslovak Chem. Communications,* May-June, **1930.**—This number is published in honor of Prof. Bohuslâv Brauner to celebrate his 75th birthday, May 8, 1930, and his 50th anniversary of obtaining his degree of Philosophiae Doctor (Prague), February 26, 1880. Contains frontispiece of Brauner, a bibliography of his scientific communications dealing largely with the rare earths (pp. 211–8), an article on Mendeléeff (see abstract on **D. I. Mendeléeff as Reflected** in **His Friendship to Professor Bohuslav Brauner** on page 2192). and numerous scientific communications by various investigators. The volume contains over 225 pages.
C. E. M.

Henry Summers Chatfield. M. H. HAERTEL. *Ind. Eng. Chem.*, **22,** 299–300 (1930).—Bibliographical sketch with portrait. D. C. L.

Karl Taylor Compton. See **Massachusetts Institute of Technology** in **Local Activities** on page 2205. M. W. G.

Life and Work of Sir Humphry Davy. J. C. GREGORY. *Sci. Progr.*, **24,** 485–98 (Jan., 1930).—A biographical sketch. C. E. M.

Frederick George Donnan. See **University College** in **Local Activities** on page 2208. M. W. G.

Albert Einstein. See **A Close Look at the World's Greatest Thinker** on page 2193. M. W. G.

G. Hevesy. See **Cornell University** in **Local Activities** on page 2204. M. W. G.

Life of Kekulé. R. ANSCHUTZ. See **The Doctrine of Atomic Valency** on page 2190 for reference to a review of this book. M. W. G.

Irving Langmuir. A. W. HULL. *Chem. Bull.*, **17,** 151–2 (May, 1930).—"Should a scientist play? Does he know how to play? What does he play? These questions are not without meaning to those who would be scientists." Dr. Langmuir is a scientist who does play; he loves the outdoors, and during week-ends one may find him at his Lake George resort. His most deeply rooted hobby is his curiosity to understand the mechanism of simple and familiar natural phenomena. The lake offers a wealth of questions, both in summer and in winter. He has made studies of lake currents, water temperatures, etc. Mountain climbing has always held a great fascination for him. Home movies is another hobby. Dr. Langmuir has answered the question, "Can a scientist find time for play?" with an emphatic "yes." "The essential factor is not time for play, but love for play, the knowledge of how to play, and the possession of a hobby." H. T. B.

Max von Laue. M. PLANCK. *Naturwissenschaften,* **17,** 787–8 (1929); *Chem. Abstr.*, **24,** 760 (Feb. 20, 1930). C. E. M.

Execution of Lavoisier on the Guillotine in 1794. M. SPETER. *Unsere Welt,* **21,** 355–8 (1929); *Chem. Zentr.*, **1930,** I, 789–90; *Chem. Abstr.*, **24,** 2922 (June 20, 1930). C. E. M.

André Le Chatelier (1861–1929). L. GUILLET. *Rev. métal.* **26,** 632 (1929); *Chem. Abstr.*, **24,** 1258 (Mar. 20, 1930).—An obituary with portrait. C. E. M.

Justus Liebig's Years of Learning and Traveling. F. HENRICH. *Z. angew. Chem.*, **42,** 1173–6 (1929); *Chem. Abstr.*, **24,** 760 (Feb. 20, 1930). C. E. M.

Richard Lorenz. Memories of Years at Zürich. G. V. HEVESY. *Helv. Chim. Acta,* **13,** 13–7 (1930); *Chem. Abstr.*, **24,** 1553 (April 10, 1930). C. E. M.

D. I. Mendeléeff as Reflected in His Friendship to Professor Bohuslav Brauner. B. BRAUNER. *Collection Czechoslovak Chem. Communications,* **2,** 219–43 (May-June, 1930).—This article on Mendeléeff was originally written in Czech and published in the journal *Pokroková Revue* as an obituary article after the death of Mendeléeff in 1907. The present article, translated into English by J. Heyrovský, appears in the number of the *Collection of Czechoslovak Chemical Communications* published in honor of Professor Bohuslav Brauner, the author. (See abstract on **Bohuslav Brauner** on page 2191.) Article is biographical and pictures this great Russian and Slavonic genius as a chemist. It contains much material as regards the chemical views and state of scientific knowledge of the year 1907. Contains also an excellent photograph of Mendeléeff and Brauner, taken in 1900. C. E. M.

William Henry Nichols. R. R. RENSHAW. *Ind. Eng. Chem.*, **22,** 394 (April, 1930).—Obituary with portrait. [See J. CHEM. EDUC., **7,** 1112 (May, 1930).]
C. E. M.

Professor K. J. P. Orton, F.R.S. A. FERGUSON. *Nature* (London), **125,** 898–9 (June 14, 1930).—An obituary and appreciation of Professor Orton of the University College of North Wales. It gives a resumé of Orton's fundamental work on the migration of halogen in the substituted acyl-anilides as well as references to his other work.
F. B. D.

Obituary of W. H. Perkin, Jr. G. J. OSTLING. *Finska Kemistsamfundets Medd.*, **38**, 57–67 (1929); *Chem. Abstr.*, **24**, 1258 (Mar. 20, 1930). C. E. M.

François Marie Raoult. ANON. *Nature* (London), **125**, 679 (May 3, 1930).—On May 10th occurs the centenary of the birth of the distinguished French chemist, François Marie Raoult. The son of a customs officer, he was educated at Laon and Paris, became a teacher, held various appointments at Rheims and elsewhere, and in 1870, at the age of forty, succeeded to the chair of chemistry at Grenoble, where the remainder of his life was passed. His earliest researches were largely connected with the phenomena of the voltaic cell, but his name is best known for his work on solutions, which occupied the last two decades of his life. His first paper on the depression of the freezing points of liquids by the presence of substances dissolved in them was published in 1878. Continued experiments with various solvents led him to the discovery of a simple relation between the molecular weights of substances and the freezing point of the solvent which he expressed in the "loi générale de la congélation." He also studied the diminution of the vapor pressure of a solvent caused by dissolving a substance in it, and his important work in these directions was afterward used by such eminent investigators as van't Hoff before the Chemical Society, of which Raoult had been elected a foreign member in 1898. A modest, retiring, and dignified man, he lived mainly for his work, the value of which was recognized by the award of prizes by the Paris Academy of Sciences and of the Davy Medal of the Royal Society. His death took place on April 1, 1901. C. E. M.

Samuel Rideal, Died 1929. J. T. A. WALKER. *Chemist Druggist*, **111**, 652 (1929); *Chem. Abstr.*, **24**, 2341 (May 20, 1930).—An appreciation and biographical review of his scientific career. C. E. M.

Schutzenberger, Scientist and Industrialist. M. BATTEGAY. *Bull. soc. ind. Mulhouse*, **95**, 680–8 (1929); *Chem. Abstr.*, **24**, 1258 (Mar. 20, 1930).—An address outlining the life and work of Schutzenberger. C. E. M.

William Boyce Thompson. ANON. *Oil, Paint Drug Reptr.*, **117**, 20 (July 7, 1930).—Obituary notice. President and founder of the Boyce Thompson Institute for Plant Research., Inc., died on June 27, 1930. [See article by Zimmerman on "The Boyce Thompson Institute for Plant Research, Inc.," J. CHEM. EDUC., **6**, 1384–402 (Sept., 1929).] C. E. M.

Seventieth Birthday of J. Traube. H. FREUNDLICH. *Kolloid-Z.*, **50**, 194–6 (1930); *Chem. Abstr.*, **24**, 2017 (May 10, 1930).—Biographical sketch with portrait. C. E. M.

Joannes Baptista von Helmont. R. B. HARVEY. *Plant Physiology*, **4**, 543–6 (1929); *Chem. Abstr.*, **24**, 999 (Mar. 10, 1930).—A biographical sketch with 3 photographs of von Helmont. C. E. M.

Dr. Harvey W. Wiley. ANON. *Oil, Paint Drug Reptr.*, **117**, 20 (July 7, 1930).—Obituary notice. Biographical notes on life of the first chief of the U. S. Bureau of Chemistry under the Food and Drugs Act and a vigorous advocate of pure foods for almost fifty years. Died June 30, 1930. C. E. M.

Some Scientific Instrument Makers of the Eighteenth Century. R. S. WHIPPLE. *Nature* (London), **125**, 829 (May 31, 1930).—In his Friday evening discourse at the Royal Institution on May 23rd, on some scientific instrument makers of the eighteenth century, Mr. R. S. Whipple stated that there is little evidence to show that scientific instrument making, as a craft, had obtained any importance in Great Britain before the sixteenth century. The demand for instruments to assist navigation became more insistent as new lands were discovered and the length of the voyages increased. The discovery of the telescope in 1608 and the development of the microscope, largely due to Hooke and Leeuwenhoek in the middle of the seventeenth century, gave a great impetus to the manufacture of scientific instruments. John Marshall, by his skill in developing a method for grinding lenses and by the improved designs of his instruments, became the foremost instrument maker of the latter part of the seventeenth and of the early part of the eighteenth century. Benjamin Martin (1704–1782), who began life as a ploughboy, later became well known as an author of popular scientific books and as instrument maker. He developed many improvements in the microscope and other instruments. One of his contemporaries, George Adams, became, perhaps, the best-known instrument maker of the eighteenth century. He specialized in the manufacture of globes and surveying instruments, and also in microscopes. He also made a large number of instruments for George III, which are preserved in the Science Museum at South Kensington. They are outstanding examples of finished workmanship. Dolland, Ramsden, and Herschel were other outstanding instrument makers of the eighteenth century. C. E. M.

Faraday's Diary. See **Cornell University** in **Local Activities** on page 2204.
M. W. G.

Faraday Centenary Celebration, 1931. See this title on page 2197.

A Close Look at the World's Greatest Thinker. M. K. WISEHART. *Am. Mag.*, June, 1930, pp. 19–21, 134–40.—Describes a visit to the home of Albert Einstein, with anecdotes illustrating his personality, home relations, and habits of life and work. Two photographs. M. A. C.

Josiah Wedgewood and His Influence on the English Pottery Industry. *Nature* (London), **125**, 781–3, 788 (May 24, 1930).—This is a sketch of Wedgewood's work in the development of ceramics between 1759 and 1795.

Wedgewood was a friend of Priestley and made notable contributions to our knowledge of glazes, colors, decorations, saggers, and, in fact, practically every department of pottery manufacture.

The article is timely since at Stoke-on-Trent the bicentenary of Wedgewood's birth was celebrated in May. One of the incidents of the pageant was a showing of scenes from the life of Wedgewood from his apprenticeship to the latter days when he had become a great industrial leader and an honored man of science. F. B. D.

Alchemy. See **The Romance of the Philosopher's Stone** below on this page.

Michael Scot and Alchemy. D. W. SINGER. *Isis*, **13**, 5–15 (1929). C. E. M.

An Alchemical Manuscript of the 14th Century and Its Relation to Albertus Magnus' Book "De Mineralibus." F. PANETH. *Arch. Ges. Math., Naturw. Tech.*, **12**, 33–45 (1929); *Chem. Zentr.*, **1930**, I, 790; *Chem. Abstr.*, **24**, 2922 (June 20, 1930).
C. E. M.

An Alchemical Recipe for Gold Attributed to King Mathias Corvinus of Hungary. L. KARL. *Archeion*, **9**, 206–9 (1929); *Chem. Abstr.*, **24**, 999 (Mar. 10, 1930). C. E. M.

The Romance of the Philosopher's Stone. J. READ. *Chem. & Ind.*, **49**, 410–5 (May 16, 1930).—An interesting, well-illustrated account of the works and beliefs of the alchemists to the time of Paracelsus. Many quotations and references are given.
E. R. W.

Practical Chemistry in the Twelfth Century: Rasis on Alums and Salts Translated by Gerard of Cremona. R. STEELE. *Isis*, **12**, 10–46 (1929); *Chem. Abstr.*, **24**, 999 (Mar. 10, 1930).—Latin text, commentary, and glossary of alchemical terms.
C. E. M.

The Honorable Robert Boyle: A Chapter in the Philosophy of Science. G. W. SPRIGGS. *Archeion*, **9**, 1–12 (1929); *Chem. Abstr.*, **24**, 999 (Mar. 10, 1930).—An account of the modern corpuscular theory of matter before John Dalton. Boyle's insistence upon the corpuscular structure of matter was perhaps one of his most important contributions to science. C. E. M.

Newton: The Emission Theory of Light and Chemical Doctrine in the Eighteenth Century. H. METZGER. *Archeion*, **9**, 13–25 (1929); *Chem. Abstr.*, **24**, 999 (Mar. 10, 1930). C. E. M.

Newton and the Exposition of Chemical Doctrine in the Eighteenth Century. H. METZGER. *Archeion*, **9**, 190–7 (1929); *Chem. Abstr.*, **24**, 999 (Mar. 10, 1930).
C. E. M.

The Doctrine of Atomic Valency. See this title on page 2190.

The Florence Flask. T. BOLAS. *Pharm. J.*, **123**, 196–7 (1929); *Chem. Abstr.*, **24**, 2331 (May 20, 1930).—Historical references (1690–1890) to the use of Italian olive oil flasks or similar glass apparatus in chemical operations are discussed. C. E. M.

Iron. Historical. See **The Metallography of Some Ancient Egyptian Implements** below on this page.

Purity of Lead at the Time of the Birth of Christ. A. EBELING AND H. ADAM. *Wiss. Veröffentlich. Siemens-Konzern*, **8**, No. 3, 203–10 (1930); *Chem. Abstr.*, **24**, 1774 (Apr. 20, 1930).—Pb from graves on the Dalmatian coast of a period prior to the birth of Christ and a section of water pipe from Pompeii were analyzed. The earlier Pb was more pure, the samples containing 99.8 and 99.3% Pb, respectively. The cause of this difference could not be established. C. E. M.

The Metallography of Some Ancient Egyptian Implements. H. CARPENTER AND J. M. ROBERTSON. *Nature* (London), **125**, 859–62 (June 7, 1930).—The evidence indicates that iron was rare until about 1300 B. C., though the Egyptians were acquainted with the metal for about fifteen hundred years before its use became general according to the evidence of specimens in the period 2900–1450 B. C.

The use would not be common until the iron implements produced were decidedly superior to the much used bronze. The authors have examined a number of specimens dating from 1200 B. C. to 200 A. D. microscopically and determined their hard-

ness with a Brinell tester. The facts disclosed by their work "constitute the first definite evidence that carburizing, quenching, and the advantages of heat treatment generally were known and understood many centuries before the Christian era."

It is probable that the iron age in Egypt did not begin until these processes were understood and a range of alloys superior to bronze were obtained. The extensive utilization of iron would seem to be due then to the discovery of carburizing and quenching. F. B. D.

American Institute of Chemists' 1930 Medal Award to George Eastman. See this title on page 2196.

Nobel Prize in Chemistry: Hans von Euler and A. Harden. K. JOSEPHSON. *Svensk Kem. Tid.*, **41**, 275–81 (1929); *Chem. Abstr.*, **24**, 1553 (Apr., 10, 1930).—A summary of the recent work of the prize winners and portraits. C. E. M.

The History of Science Society. See this title in **Local Activities** on page 2201. M. W. G.

EDUCATIONAL MEASUREMENTS AND DATA

Size of Classes at The Ohio State University. ANON. *Sch. & Soc.*, **31**, 561 (Apr. 26, 1930).—The Ohio State University reports its campaign to reduce oversized classes so as to give greater attention to individual students, particularly freshmen, has been successful during the past four years to the extent of decreasing the average elementary class from 37 to 29 pupils. C. E. M.

The National Survey of Secondary Education. ANON. *Sch. & Soc.*, **31**, 763 (June 7, 1930).—The four major projects of the national survey of secondary education now under way involve: (1) the organization of schools and districts; (2) secondary school population and related problems; (3) administration and supervision; and (4) classification and analysis of curriculum researches in the secondary field. Various plans of conducting the investigation were discussed by the committee at its meeting in Washington, D. C., May 24th and 26th.

THE PHILOSOPHY OF EDUCATION

Education, Savage and Civilized. J. L. DAVIES. *Harpers*, Apr., 1930.—For purposes of comparison a savage community is defined as one where there is hardly any progress from one generation to another and where change is looked on with more than suspicion, while a civilized community is one wherein progress and change are the life blood of every activity. The education in these two types of communities is compared as it affects obedience, courage, truth, sex, reticence, perseverance, and actual classroom instruction. J. W. H.

The Effect of Environment on Intelligence. F. N. FREEMAN. *Sch. & Soc.*, **31**, 623–32 (May 10, 1930).—See Editor's Outlook in July, 1930, JOURNAL OF CHEMICAL EDUCATION, pages 1490–1. K. S. H.

Aspirational Notions of Leadership. D. SNEDDEN. *Sch. & Soc.*, **31**, 661–4 (May 17, 1930).—See Editor's Outlook in August, 1930, JOURNAL OF CHEMICAL EDUCATION, pages 1735–6. K. S. H.

Educational Advance through Scientific Research. A. J. STODDARD. *Sch. Exec. Mag.*, **49**, 403 (May, 1930).—There is still much confusion as to the meaning associated with the term "educational research." Several viewpoints are compared and it is prophesied that the one which will be most generally accepted will regard it as critical, reflective thinking about problems of education. The conclusion is expected to be dependable but not necessarily final.

Practically all school systems include the following as functions of their research departments: measurement of pupil achievement; group and individual psychological testing; curriculum revision; appraisal of classroom methods and experiments in creating new instructional methods and procedures. Many cities combine other functions with these.

Many of the most fundamental problems are still unsolved as: waste due to ineffective teaching methods; proper sizes of classes; best school accounting systems; methods of selecting candidate teachers; curricula for backward children; school building construction.

A plea is made for a National Research Agency. J. W. H.

Numerical Approximations Neglected in Both Chemistry and Physics. R. PANEBIANCO. *Schola et vita*, **4**, 163–72 (1929); *Chem. Abstr.*, **24**, 2341 (May 20, 1930).—The errors introduced into chemical and physical data by the neglect or the incorrect application of the theory of approximations are pointed out and discussed with illustrative examples. C. E. M.

THE PHILOSOPHY OF SCIENCE

Modern Corpuscular Theory of Matter before John Dalton. See **The Honorable Robert Boyle: A Chapter in the Philosophy of Science** on page 2194.

Bibliochresis: The Pilot of Research. See digest under this title on page 2181.

PROFESSIONAL

Federal Survey of Teachers. U. S. Dept. of the Interior. See this title in **Local Activities** on page 2200. M. W. G.

Propaganda by Public Utility Corporations. E. R. A. SELIGMAN. *Bull. Am. Assoc. Univ. Profs.*, **16**, 349–68 (May, 1930).—See digest under this title on pages 2180–1. B. C. H.

Preliminary Report of the Committee on Ethics of the American Association of University Professors. See digest on **Propaganda by Public Utility Corporations** on pages 2180–1. M. W. G.

Required Courses in Education. COMMITTEE Q. *Bull. Am. Assoc. Univ. Profs.*, **16**, 369–72 (May, 1930).—This is an abstract of the report presented by this committee at the association's annual meeting in December, 1929.

Citation to and quotations from literature upon the two sides of professional educational requirements for teachers in high schools, colleges, and universities are followed by specific recommendations that:

1. A commission be appointed by the American Council on Education "consisting largely of specialists in education, to investigate the problem of required courses in education for prospective teachers in secondary schools and colleges with a view to establishing the facts objectively."

2. The officers of the American Association of University Professors coöperate with other organizations for the purpose of obtaining from the General Education Board, or some similar agency, a special grant of funds such as would be needed for the proposed investigation. B. C. H.

CONTEMPORARY NEWS AND COMMENTS IN CHEMISTRY AND EDUCATION

Recent Developments in Chemical Education. O. M. SMITH. *Univ. Okla. Bull.*, **9**, 10–9 (Nov. 15, 1929).—Presidential address, Oklahoma Academy of Science, Nov. 30, 1928. The author points out some important trends in the field of chemical education in the United States, citing as evidence quotations from numerous articles which have appeared in the JOURNAL OF CHEMICAL EDUCATION. Attention is called to the present organizations of chemistry teachers and their program; to the new cultural chemistry now under trial and being recommended for high-school and non-professional courses in the colleges and universities, and the questioning attitude of many educators on the value of laboratory work. C. E. M.

Independent Study Plan at the George Washington University. See digest on **The American University Looks Ahead** on pages 2179–80.

Curriculum Revision at the University of Wisconsin. See digest on **The American University Looks Ahead** on pages 2179–80.

Preliminary Report of the Committee on Ethics of the American Association of University Professors. See digest on **Propaganda by Public Utility Corporations** on pages 2180–1.

Federal Survey of Teachers. U. S. Dept. of the Interior. See this title in **Local Activities** on page 2200. M. W. G.

Research Information Service in Field of Secondary and Higher Education Organized by the American Association of University Women. See **American Association of University Women** in **Local Activities** on page 2202. M. W. G.

National Academy of Sciences. See this title in **Local Activities** on page 2202. M. W. G.

National Research Council Appointments for 1930–31. See **National Research Council** in **Local Activities** on page 2202. M. W. G.

University of Mississippi. See this title in **Local Activities** on page 2207. M. W. G.

Survey of Present Status of Nitrogen Fertilizer Research in the United States and Europe. See **University of California** in **Local Activities** on page 2207. M. W. G.

Beilby Memorial Awards. See this title in **Local Activities** on page 2209. M. W. G.

American Institute of Chemists' 1930 Medal Award to George Eastman. *Chemist,*

7 (June, 1930).—This issue of *The Chemist* contains a full account of the 1930 medal award of the Institute to Eastman of the Eastman Kodak Co. C. E. M.

Awards of the Franklin Institute. *Science*, **71**, 501 (May 16, 1930).—See this title in **Local Activities** on page 2201. G. H. W.

Franklin Institute Medal Day Address Delivered by Sir William Henry Bragg. See **The Meaning of the Crystal** on page 2191.

Award of Society of Arts and Sciences to G. N. Lewis. See **Symmetry of Time in Physics** on page 2191.

Chandler Lecture, 1929. Electrochemical Interactions of Tungsten, Thorium, Cesium, and Oxygen. I. LANGMUIR. *Ind. Eng. Chem.*, **22**, 390–3 (Apr., 1930).—Introductory paragraphs give information regarding The Charles Frederick Chandler Foundation. D. C. L.

Professor Einstein's Address at the University of Nottingham. *Science*, **71**, 608–10 (June 13, 1930).—A reprint of the stenographic report of the translation of Dr. Einstein's address on the trend of modern physics. The report was originally cabled to the *New York Times* and is published by its permission in *Science*. G. H. W.

Chemistry in the Museum of Science and Industry. L. EHRENFELD. *Chem. Bull.*, **17**, 187 (June, 1930).—The Museum of Science and Industry will be an exact replica of the Old Fine Arts Building of the World's Columbian Exposition of 1893, and located on the site of the original in Jackson Park in Chicago. [*Cf.* Waldemar Kaempffert, *Sci. Mo.*, **28**, 481 (1929).] Chemistry will be presented both as pure and applied science, and as an economic and social force responsible for great changes in the economic and social structure of whole nations.

If, on entering the building, one decides to follow the arrangement designated as the physical sciences, he sees first the sciences evolving from primitive astronomy, then the alchemist's laboratory, and on to the modern research laboratory. Many industrial processes will be exhibited. A striking feature is that the exhibits may be operated by the visitor at the push of a button. These model factories are equipped with flow sheets so that the essential processes are laid bare.

Much assistance in the project must come from chemists and the chemical industry in order to attain the purpose for which the museum is planned. H. T. B.

The World's Fair at Chicago. M. HOLLAND. *Sci. Mo.*, **31**, 93 (July, 1930).—Note of the exposition philosophy for the next Chicago World's Fair, scheduled to open in 1933. Illustrated. C. E. M.

Prize Offered for New Applications of Mercury. See this title in **Local Activities** on page 2202. M. W. G.

Eighth Annual High-School Chemistry Contest, Sacramento Section, A. C. S. See this title in **Local Activities** on page 2203. M. W. G.

Pacific Coast Chemistry Contest. See this title in **Local Activities** on page 2203. M. W. G.

Second Annual Contest for High-School Chemistry Teams, Oregon Section, A. C. S. See this title in **Local Activities** on page 2203. M. W. G.

The History of Science Society. See this title in **Local Activities** on page 2201. M. W. G.

New Research Laboratory of the Aluminum Company of America. ANON. *Ind. Eng. Chem., News Ed.*, **8**, 1–2 (July 10, 1930).—Description with illustrations. [See J. CHEM. EDUC., **7**, 1980 (Aug., 1930).] D. C. L.

Faraday Centenary Celebration, 1931. ANON. *Chem. News*, **140**, 394–5 (June 20, 1930); *Ibid.*, 411–2 (June 27, 1930).—A report on the progress of the arrangements to celebrate in 1931 the centenary of Faraday's discovery of electro-magnetic induction. The report includes information concerning the date of the centenary, the organization of the celebrations, the institutions coöperating in the arrangements, and the provisional program and dates. C. E. M.

Second Scientific Congress, Mexico. See this title in **Local Activities** on page 2209. M. W. G.

Achema VI Exhibition of Chemical Apparatus. See this title in **Local Activities** on page 2209. M. W. G.

FOREIGN CHEMICAL AND EDUCATIONAL CONDITIONS

Research Work in Germany from 1920–27. *Nature*, **125**, 831 (May 31, 1930).—"Research work in Germany from 1920 to 1927 is outlined in 'Deutsche Forschung,' a brochure issued as an extract from the fifth Report of the Notgemeinschaft der Deutschen Wissenschaft. Its 116 pages give some idea of the immense range of activities encouraged by thousands of grants-in-aid during years of impoverishment. All academic

studies have benefited from theology, philosophy, and philology to biology, agriculture, and medicine. Assistance has taken such forms as subventions for printing expenses of periodicals, grants to research scholars and explorers, publication of works almost completed before the war, provision of expensive physical apparatus and foreign literature. In every department it has been necessary to consider which magazines to support, and in restricting quantity to improve quality; hence, two are supported for international law, three for psychology, ten for geology. The most striking venture has been the exploration of the South Atlantic by the research ship *Meteor*. Some two years were spent on about a dozen roughly parallel routes between Africa and South America. Sea and air, winds and currents, plankton and ocean floor were examined by specialists. Other leading lines have been vitamins, ultra-violet and penetrating radiations, cathode rays, vacuum tubes, and spectroscopy. Preparations have been made for total eclipse expeditions and for observations of the opposition of Eros. As a guide to recent research in Germany the book should be valuable to the historians of science and to publishers, editors, and librarians." C. E. M.

The 1851 Exhibition Commissioners and Their Work. F. G. OGILVIE. *Nature* (London), **125**, 929–32, 976–9 (June 21, 28, 1930).—"The Royal Commission for the Exhibition of 1851" was incorporated in 1850 under royal sanction for the immediate purpose of managing an exhibition in 1851 of an international character. The foresight of the organizers was such, however, that the Commission is still in existence and during the past 75 years has rendered service of inestimable value to both material and intellectual progress in the science, art, and industry of Great Britain. Its Science Research Scholarship scheme (it was one of these scholarships which brought Rutherford to England, see page 493 of the March, 1930, J. CHEM. EDUC.), whereby worthy students have been afforded opportunity to continue scientific research, has been the source of some of the most fruitful contributions to the progress of science during the present century. From 1891–1929 there were 562 scholarships awarded, details regarding which are contained in this article.

A wide survey of other ventures of the Commission with mention of its prominent achievements in furthering science or the arts, or of stimulating inventions or industries, is given. C. E. M.

GENERAL

Organization of Industrial Research. E. B. BENGER. *Ind. Eng. Chem.*, **22**, 572 (June, 1930).—Organization is essential wherever the concerted action of a number of people is involved in obtaining a certain result. Research is an individual or personal affair, since research is creative, and creative work is done by individuals rather than groups. Organization is here considered as a means of increasing the individual's creative ability by distracting him as little as possible by incidentals of work that can be done equally well by others. It is discussed under five heads. (1) *Securing the man.* After his selection according to qualifications, it is necessary to give him a number of shorter problems to see whether he is fitted for research, or should be shifted to another department. (2) *Providing the money.* This of course varies in different companies, and may vary considerably from year to year, so that a fairly large part of the organization may not be permanent. (3) *Furnishing the atmosphere.* An atmosphere of confidence and success is necessary. A man must be made to feel that his superiors have no anxiety concerning the results, and that he alone is in charge of it. He must be encouraged to keep in touch with advancements of science and other parts of his own company and other organizations of a similar nature. (4) *Accessory service.* Numerous ways in which the research man can be aided are in stenographic service, library service, purchase of supplies and apparatus, having analytical work done by the laboratory, etc. (5) *Capitalization of results.* Results are often intangible, but usually they are much more valuable than is realized unless an actual accounting is made. D. C. L.

Migration of Chemical Industry. C. W. CUNO. *Ind. Eng. Chem.*, **22**, 588–90 (June, 1930).—Industries often tend to centralize in certain localities, *e. g.*, rubber, automobile, steel. Migration tendencies are less obvious, but nevertheless as positive. Twenty-five years has seen the shift of 26% H_2SO_4 manufactures to the South, ten years the shift of 50% rayon manufacture to the Carolinas and Virginia. The predominating factors in influencing migration are: (1) Migration of population. (2) Shift of raw material centers. (3) Shift of predominating demand due to new applications and inventions. (4) New sources of fuel or power, due to development of hydroelectric power, technical processes of utilizing inferior fuels, or development of new fuel fields. (5) Exploitation of new sources of labor. (6) Development

of centers of distribution, usually through freight territory demands and freight differentials. D. C. L.

Industrial Research and Education. W. A. HAMOR. *Pittsburgh Record*, **4**, 54–7 (June, 1930).—The educational functions of a research institution are outlined. C. E. M.

The Commerce of Chemistry. J. N. TAYLOR. *Am. J. Pharm.*, **102**, 254–63 (May, 1930).—Today there is a necessity for a larger knowledge of economic conditions as they affect the chemical industry. The mutual relationship between chemical production and distributive mediums has introduced a new chemist classification—the chemical marketing specialist, who will have a basic knowledge of chemical science; who will understand the fundamental aspects of chemical processes, the relation of one product to another, the possibilities for new and more efficient applications of them, as well as a more intelligent understanding of economic trends. More emphasis must be laid upon the commercial distribution of chemical wares. It is not enough to visualize the development, but practical methods for bringing about the desired ends must be formulated. The method of approach suggested by the writer as capable of specific application is a chemical-economic survey which should show fairly conclusively whether or not a given material shall go into production, how long an industry can continue, whether it should pick up and move to some other part of the country, or whether it should switch gradually. Not so long ago the number of synthetic products was small. Today the utilization of wastes is constantly changing our ideas as to what are main products and what are by-products. The commerce of chemistry is a sort of "reversible reaction" in that the fortunes of one are bound up with those of the other. G. O.

The Influence of Technic on Research. F. A. FREETH. *Chem. Age*, **22**, 436–7 (May 10, 1930).—Technic is the proper control of the variables of nature and the method of manipulating matter and subjecting it to treatment under the most varied conditions. Examples of fine technic will be found in the works of Sir William Ramsay and Kamerlingh Onnes. Research in England is hampered by a scarcity of fine mechanics and glass-blowers. The lack of highly skilled workers along these lines slows down the adoption of new apparatus and methods of attack as the initial cost is in many cases too high. Thus what might seem to be an insignificant detail is in reality a limiting factor in the amount and quality of research. E. R. W.

Bibliochresis: The Pilot of Research. W. A. HAMOR AND L. W. BASS. *Science*, **71**, 375–8 (Apr. 11, 1930).—See digest under this title on pages 2181–4. G. H. W.

Chemical Warfare Training for the Soldier—A Necessity and a Practical Possibility. M. J. MORIN. *Chem. Warfare*, **16**, 757–60 (May, 1930).—Post-war statistics have established the fact that men wounded by gas had twelve times more chances for living than if wounded by other weapons. Gas was responsible for one-third of the total casualties. The use of chemicals is to be expected in all major wars of the future. The paper is principally concerned with an outline of a plan for the training of the army in the use of, and in protection against, poison gases. E. R. W.

Virginia County Pays Teachers for What Pupils Learn. School teachers are paid for what their pupils learn in Montgomery county, Virginia. The pupils are given mental tests at the beginning and end of the year and those who have learned most earn their instructors a $200 bonus. This is one accomplishment of a new form of administration tried out last year by Dr. Minor Wine Thomas of the State Teachers' College at East Radford, Va. The plan also enabled 25 per cent fewer teachers to give 13 per cent more pupils one and a half times as much knowledge as they learned under the old system in use the previous year and practiced largely throughout the country. Under the salary schedule, planned to stimulate teachers' efforts, they are paid 10 cents a day for each child present. A basic salary of $10 a month for each year of college education is also given. Teachers of one-room schools are allowed $5 a month additional for administrative work. The system also increased the average salary of teachers 15 per cent and decreased slightly the total cost of salaries. The saving was used to buy supplementary material. An average daily attendance increase of 18 per cent also resulted.—*Science Service*

Local Activities

Purpose and Organization

The purpose of the Local Activities Section of the JOURNAL OF CHEMICAL EDUCATION is briefly but clearly stated in its title. Any items of local news from institutions, A. C. S. Sections, Teachers' Associations, or other organizations which are of such a nature as to make them of more than purely local interest rightfully belong to this Section.

The responsibility of reporting items for this section rests entirely with the local institutions and organizations. It is desirable to have a representative appointed to report news regularly. Suitable material sent to the editorial office before the 20th of each month will be published in the following month's journal. The Editorial Staff must necessarily reserve the right to abridge or totally reject any items submitted. If the following suggestions are followed, however, the necessity for such action will be largely obviated.

Material to Be Reported

1. Notices of local scholarships or fellowships and announcements of new or unusual courses in chemical education or special fields of chemistry.
2. Reports of dedication of new science buildings, stressing the unique features.
3. News notes concerning activities of prominent scientists and educators and of the honors and awards made to them.
4. Promotions within, or changes of, personnel of a department.
5. Notices of any special gifts to chemical organizations or departments—as fellowships, endowments, laboratory gifts, library gifts, etc.
6. Accounts of meetings, social functions, exhibitions, chemical entertainments, etc., which might be suggestive to other organizations. Where original or unusual features are included, it is desirable that they be described in some detail.

Federal Survey of Teachers, U. S. Department of the Interior. The Department of the Interior through its Office of Education is proceeding "to make a study of the qualifications of teachers in the public schools, the supply of available teachers, the facilities available and needed for teacher training, including courses of study and methods of teaching," as authorized by the recent Congress.

Secretary Wilbur has announced the appointment of DR. EDWARD S. EVENDEN of Columbia University as associate director of the teacher training survey, working under DR. WILLIAM JOHN COOPER, Commissioner of Education, who will function as director. DR. BEN FRASIER of the Office of Education will officiate as administrative assistant in this study.

Dr. Evenden has been connected with Teachers' College, Columbia University, New York City, since 1918. Beginning with that institution he was first an associate in the department of educational administration for two years, then assistant professor of education for two years, associate professor for one year, and since 1923, professor. Before coming to Columbia he had been head of the Department of Education of the State Normal School at Monmouth, Oregon. Prior to that he was critic teacher and superintendent of schools. He had graduated from the State Normal School at Monmouth in 1903, and later had received the A.B. and the A.M. degrees from Stanford University and a Ph.D. degree from the Teachers' College of Columbia University.

The recent Congress provided $200,000 to be used in this study of teacher training. Of this, $50,000 is available for expenditures during the present year.

Secretary Wilbur also announces the appointment of a group of eminent specialists to constitute a board of consultants to act as advisers in this undertaking. They are as follows:

JOHN A. H. KEITH, Superintendent of Public Instruction of the State of Pennsylvania, as a representative of the National Council of State Superintendents and Commissioners of Education, and a member of the original survey committee of 1915; W. P. MORGAN, president of the State Teachers' College, Macomb, Illinois, past president of the North Central Association of Colleges and Secondary Schools, and also past president of the American Association of Teachers' Col-

leges; D. B. WALDO, president of the Western State Teachers' College, Kalamazoo, Michigan, active in the American Association of Teachers' Colleges for many years and also a member of the original 1915 survey committee; GEORGE W. FRASIER, president of the Colorado State Teachers' College, Greeley, Colorado, the present president of the American Association of Teachers' Colleges; WILLIAM WEBB KEMP, dean of the School of Education, University of California, a representative of the Association of Deans of Education in State Universities and Land-Grant Colleges; M. E. HAGGERTY, dean of the School of Education in the University of Minnesota, one of the most active men in formulating the movements which brought about this survey; WILLIAM C. BAGLEY, in charge of the Division of Teacher Preparation, Columbia University, an exponent of "professionalized subject matter;" WILLIAM S. GRAY, dean of the School of Education, University of Chicago; HENRY W. HOLMES, dean of the Graduate School of Education, Harvard University, an exponent of the two years' course for the master's degree in education for teachers; SHELTON PHELPS, George Peabody College for Teachers; and W. W. CHARTERS, Ohio State University, who conducted the Commonwealth Fund study in analyzing the work of the teacher.

Franklin Institute. We learn from *Science* of the following awards of this Institute:

The medal meeting of the Franklin Institute, Philadelphia, was held on the afternoon of May 21st. On this occasion honorary membership was conferred on DR. MORTIMER ELWYN COOLEY, dean emeritus of the College of Engineering of the University of Michigan, and on DR. HENRY LEFFMANN, of the Franklin Institute. The *Certificate of Merit* was presented to HEYMAN ROSENBERG of the Parker-Kalon Corporation, New York City. Medals were presented as follows: *Longstreth Medals* to ERVIN GEORGE BAILEY, Fuller-Lehigh Company, Fullerton, Pennsylvania, and to CHARLES WEYL, assistant professor of electrical engineering, University of Pennsylvania; the *Wetherill Medals* to CHARLES SUMNER CHRISMAN, West Chester, Pennsylvania, and to WILLIAM NICHOLSON JENNINGS, Philadelphia, Pennsylvania; the *Levy Medal* to DR. FLOYD KARKER RICHTMYER, professor of physics, Cornell University; *Henderson Medals* to GEORGE HANNAUER (posthumous award), represented by GEORGE HANNAUER, JR., Chestnut Hill, Massachusetts; EDGAR MARVIN WILCOX, Hannauer Car Retarder Company, Gibson, Indiana; the *Clark Medal* to HENRY LATHAM DOHERTY, Cities Service Company, New York City; *Cresson Medals* to NORMAN ROTHWELL GIBSON, The Niagara Falls Power Company, and to IRVING EDWIN MOULTROP, The Edison Electric Illuminating Company, Boston; the *Franklin Medals and Certificates of Honorary Membership* to DR. JOHN FRANK STEVENS, former chief engineer of the Panama Canal, and to SIR WILLIAM HENRY BRAGG, director of the Royal Institution of Great Britain. A dinner in honor of the medalists was given in the evening at the Bellevue-Stratford Hotel.

The History of Science Society. We learn from the report of the secretaries of this society, published in *Science*, that the body met concurrently with the American Historical Association at Durham and Chapel Hill, North Carolina, on December 30–31, 1929, and January 1, 1930. This was the tenth anniversary of the History of Science group of the American Historical Association, which was inaugurated in 1920 by DR. LYNN THORNDIKE, of Columbia University. The following year a similar section was instituted by the American Association for the Advancement of Science. In 1924 under the direction of DR. DAVID EUGENE SMITH, of Columbia, the two groups combined to form the History of Science Society. Dr. Thorndike is now

its president. The next meeting of the society will be concurrent with the meeting of the American Association for the Advancement of Science during this year in Cleveland.

American Association of University Women. We learn from *School and Society* that this association has recently announced the organization of a research information service in the field of secondary and higher education, at 1634 Eye Street, Washington, D. C. Requests for information should be addressed to the executive and educational secretary.

National Academy of Sciences. *Science* announces that the first meeting of the National Academy of Sciences to be held west of Wisconsin will take place from September 18th to 23rd, opening at the University of California, moving to Stanford University on the third day, and to the California Institute of Technology for the last two days. The body will be welcomed to the three institutions by PRESIDENT ROBERT GORDON SPROUL of the University of California; ACTING PRESIDENT ROBERT E. SWAIN, of Stanford, a contributing editor of the JOURNAL OF CHEMICAL EDUCATION; and DR. ROBERT A. MILLIKAN, chairman of the executive council of the California Institute of Technology.

National Research Council. The Division of Chemistry and Chemical Technology of the National Research Council has announced the following appointments for 1930–31, according to the *News Edition* of *Industrial and Engineering Chemistry:* **Chairman,** HARRY A. CURTIS; **Vice Chairman,** HENRY K. BENSON (contributing editor from the State of Washington to the JOURNAL OF CHEMICAL EDUCATION); **American Chemical Society,** MARSTON T. BOGERT, WM. MANSFIELD CLARK, JAMES B. CONANT, EDWARD ELLERY, ARTHUR B. LAMB, CHARLES M. A. STINE, MOSES GOMBERG, CHARLES L. PARSONS, EDWARD R. WEIDLEIN; **American Electrochemical Society,** ROBERT M. BURNS; **American Institute of Chemical Engineers,** WALTER L. BADGER; **American Ceramic Society,** HOBART M. KRANER; **Representative of Division of Federal Relations,** HENRY G. KNIGHT; **Members-at-large,** EDWARD MACK, JR., FRANK C. WHITMORE, GEORGE A. HULETT, FREDERICK G. KEYES, JAMES E. MILLS, HARLAN S. MINER; **Liaison Member from Division of Biology and Agriculture,** ROSS A. GORTNER; **Ex Officio, American Vice-President, International Union of Pure and Applied Chemistry,** CHARLES L. REESE.

Prize Offered for New Applications of Mercury. We quote the following announcement from *Science:*

The European producers of mercury, desiring new uses for the metal, have offered a prize under the following stipulations: (1) A prize will be awarded, under the conditions below, to whoever proves to a commission of the European producers to have found a new use for mercury or its salts, and to have industrially exploited it, to the extent of the use being defined as in (3) below. (2) The use should be as yet unknown to the industry, and should be regularly and definitely protected by patent not before January 1, 1930, in Germany and the United States. (3) The application must be important enough to indicate a new consumption of mercury of at least 1000 flasks during 1930, 3000 in 1934, and 5000 in 1935. (4) The prize will be awarded by a commission consisting of the president and vice-president of the European producers and two technicians named by the Spanish Academy of Sciences and the Academy of Italy, or their representatives. The prize will be £5000 sterling, £1000 to be paid immediately upon the decision of the commission; £2000, one year after the condition in (3) above has been confirmed, and £2000 two years after the condition in (3) has been confirmed and the consumption of the metal estimated prac-

tically and confirmed by the commission. (5) The commission may delay the award, reduce its value or prolong the period of offer without giving any reason for its action. (6) The decision of the commission is final without notification of reasons. (7) The complete account of the studies and practical experiments relating to the new application should be presented in quadruplicate, printed or typewritten either in Spanish, Italian, German, English, or French, and should be sent, registered, to Mercurio Europeo, Bureau de Repartition, Plaza St. François 5, Lausanne, Switzerland, from which further information may be obtained.

Second Annual Contest for High-School Chemistry Teams, Oregon Section, A. C. S. Eighteen teams from Oregon and Southwestern Washington competed in the second annual contest for high-school teams sponsored by the Oregon Section of the A. C. S.

The winning teams were: first place, Hood River High School, Hood River; second place, Columbia University High School, Portland; third place, Lincoln High School, Portland; fourth place, Jefferson High School, Portland; fifth place, Washington High School, Portland.

The members of the Hood River team were LLOYD and LESTER VAN BLARICOM, BYRON and WALLACE MILLER (two pairs of brothers), and IVAN WOODS. It should be mentioned that MR. J. H. CRENSHAW, their instructor, is a member of the A. C. S., spray chemist for the Hood River Apple Growers Association, and a graduate student of chemistry at the University of Washington.

Columbia University High-School team won the contest last year and made an excellent showing. There was less than one and one-half per cent difference among the next three teams, all of which are in the Portland City School System.

The Hood River team was awarded a bronze replica of a volumetric flask, suitably engraved, which was donated by the Braun-Knecht-Heimann Co. of San Francisco. This was presented during their commencement exercises.

There was considerable variation in the performance of the teams. The highest team made a weighted average of seventy-five per cent, while the lowest averaged thirty-five per cent, the mean being fifty-five per cent. No attempt was made to make the examination easy.

The committee conducting the contest consisted of PROFESSOR JOHN FULTON, Oregon State College, chairman; PROFESSOR O. F. STAFFORD, University of Oregon, and DR. R. K. STRONG, Reed College, Portland, assisted by officers and members of the college chemistry staffs.

Eighth Annual High-School Chemistry Contest, Sacramento Section, A. C. S. This contest was held in June last with the result that Roseville team won first place, with an average of 86.4%; Stockton, second, with 80.7%, and Sacramento, third, with 79.1%.

The Roseville team was composed of WILLIAM PRIEST, WILLIAM J. FURUTA, JIM N. YORK, and MILO L. TALLY. William Priest, who attained the highest individual grade in this contest, 96%, also had the distinction of taking first place as an individual in the Pacific Coast Chemistry Contest (see below) with a grade of 95.5%.

Pacific Coast Chemistry Contest. The first Pacific Coast Chemistry Contest among high-school teams which were winners in their local A. C. S. sectional contests was held at the University of Oregon during the Eugene Meeting of the A. A. A. S. on June 18, 1930.

Teams representing the Sacramento Section (Roseville High School, California) and the Oregon Section (Hood River High School) competed.

Formal announcement that the Oregon team won the contest was made at the chemist's banquet by PROFESSOR C. R. KINNEY of the University of Utah who conducted the written examination. A

trophy, consisting of a silver cup, properly inscribed, was awarded. The cup was donated by the Braun-Knecht-Heimann Co. and will be presented annually to the winning team in similar contests.

PROFESSOR J. H. NORTON of the Sacramento Section was largely responsible for the promotion of and arrangements for this contest. It is hoped that other Pacific Coast Sections will participate in the second annual contest which will be held during the A. A. A. S. Pacific Coast Meeting in June, 1931. Already interest in this contest has increased and the Puget Sound Section of the A. C. S. has stated that it will sponsor a sectional contest and send its winning team next year.

Antioch College. *School and Society* announces that DR. AUSTIN M. PATTERSON, professor of chemistry at Antioch, was recently elected vice-president of the college by the board of trustees at their annual meeting.

Cornell University. SIR WILLIAM BRAGG addressed an audience of several hundred scientists at Cornell on June 23rd and read some hitherto unpublished portions of Michael Faraday's diary. He announced that the diary will be published in full in six volumes on August 29, 1931, which, from the date entered in the diary, has now been established as the centenary of the dynamo.

We learn from the *News Edition* of *Industrial and Engineering Chemistry* that the Non-Resident Lecturer in Chemistry at Cornell under the George Fischer Baker Foundation for the first term of the year 1930–31 will be G. HEVESY, of the University of Freiburg, who will lecture on "Chemical Analysis by X-Rays and Its Applications."

Evansville College. At the close of the school year, two talking films were shown to the chemistry students at a local theater. These were "Oil Films on Water" and "Atomic Hydrogen Welding," both by DR. IRVING LANGMUIR. About 100 students formed the audience.

CLAUDE ABSHIER, assistant in chemistry during last year and the summer session, will hold a similar position during the coming school year at the Missouri School of Mines and Metallurgy.

The full year courses in general and organic chemistry given during the summer session of eight weeks are proving very popular. All students work from 7 A.M. to 12 M. daily.

To facilitate the conductance of laboratory work, classes in general chemistry during the coming year will have two 3-hour laboratory periods instead of two 2-hour periods.

Grove City College. The board of trustees of Grove City College have announced plans for the immediate construction of a building to house the departments of chemistry, physics, and biology. The building is to be of pressed brick, trimmed with Indiana limestone. It will be 209 by 79 ft., and three stories high. A lecture room to seat 200 will accommodate large sections in all three sciences, while smaller lecture rooms will be devoted to the needs of each science.

The department of chemistry will occupy approximately half the building. There will be laboratories for general, quantitative, organic, physical, and industrial chemistry with special laboratories for foods, water analysis, and fuel and gas analysis. Offices and private laboratories to accommodate the staff will be provided in connection with each laboratory grouping. The estimated cost of the building is $300,000. CREIG S. HOYT is the head of the department of chemistry.

Hiram College. MR. PAUL FERGUSON, who has been on the staff at Cornell University for the past two years, has been made instructor in chemistry at Hiram College, beginning September, 1930.

DR. PAUL H. FALL, head of the department of chemistry at Hiram College,

has been made Acting Dean of the College for the year 1930–31. Dr. Fall is teaching in Kent State College during the summer term of 1930.

MISS NAOMA GREEN and MISS ELEANOR DELFS, who were graduated from Hiram College last June, were the only members of the senior class to receive all-college honors for high scholarship during their four years college work. Miss Green will take graduate work in chemistry at Syracuse University, where she has received an assistantship in that department. Miss Delfs has received a graduate scholarship at Oberlin College, where she will work on a colloid problem with DR. HARRY N. HOLMES.

MESSRS. PAUL PINE and UDELL GREENE, who received assistantships in chemistry at Williams College after graduating from Hiram College in 1929, have both been reappointed for the year 1930–31. MR. HOWARD THOMPSON, also of the class of '29, Hiram, who held a graduate fellowship last year in the department of chemistry at Western Reserve University, has been reappointed for the year 1930–31. All three of these men are doing research work in chemistry during the present summer with industrial companies in Elyria, Painesville, and Cleveland, respectively.

Iowa State College. According to *Science*, PROFESSOR R. A. MORTON of the University of Liverpool, lectured at the Iowa State College from June 11th to 13th on the study of absorption spectra and applications of this study to chemistry and to biological problems.

The Johns Hopkins University. The Central Scientific Company has contributed a four-year fellowship at $1000 per annum to the National Fellowship plan operating under the Chair of Chemical Education in the department of chemistry. This is to be known as the Central Scientific Fellowship and it will be awarded to a student from the state of Illinois.

Massachusetts Institute of Technology. DR. KARL TAYLOR COMPTON, former chairman of the Department of Physics of Harvard University, was inaugurated on June 6th as eleventh president of the Massachusetts Institute of Technology. On his withdrawal from its faculty, Harvard conferred its doctorate of laws on Dr. Compton, who has also been recently honored with the doctorate of science from Princeton University and the Brooklyn Polytechnic Institute.

McKendree College. KENDALL E. BORN, former student assistant in chemistry and a graduate of the department, was recently appointed to a fellowship in Vanderbilt University.

The Ohio State University. PROFESSOR WILLIAM LLOYD EVANS, chairman of the department of chemistry, accompanied by his wife and daughter, sailed from Montreal for Glasgow July 18th on S. S. Minnedosa of the Canadian Pacific Line. Dr. Evans is one of the delegates from the National Academy of Science and the National Research Council to the Tenth International Union of Pure and Applied Chemistry which will be held in Liége about the middle of September. Previous to the Congress Dr. Evans will visit Scotland, Wales, England, France, Italy, Switzerland, Germany, Belgium, and Holland.

MR. SAM A. ARONOFF (B.Ch.E., 1927) is with the Spencer-Kellogg and Son, Inc., of Chicago, Ill. He is refining superintendent of their Chicago plant in which he laid out and installed the refining equipment. He also installed equipment for a core-oil manufacturing plant, has developed oil refining methods and has been in charge of refining and hydrogenation of cocoanut oil and cocoanut stearine.

MR. WILLARD B. MITCHENER (B.Ch.E., 1927) was a recent visitor in the department of chemical engineering. Mr. Mitchener is connected with the Parke, Davis Company of Detroit, Michigan.

LYLE KERMIT HERNDON, a graduate

student in chemical engineering, is the author of two publications that have just been issued: (*a*) "Stream Pollution in West Virginia," *American Journal of Public Health*, and (*b*) "Pollution of the Cheat River," *West Virginia Wild Life Magazine*.

MR. H. C. MOORE (B.Ch.E., 1907) of Chicago, Ill., is divisional secretary of the Fertilizer Division of the A. C. S.

MR. RALPH J. PADDOCK (M.Sc. in Ch.E., 1926) was a recent visitor in the Chemical Engineering Department. Mr. Paddock is in charge of electro-plating with the Aluminum Mfg. Co. of Manitowac, Wisconsin. MR. MORRIS HURWITZ, a former student in chemical engineering, also visited the university recently. Mr. Hurwitz is now laboratory testing engineer with the Carbide and Carbon Chemicals Company of South Charleston, W. Va.

MR. ERNEST T. HANDLEY (B.Ch.E., 1923) spent a portion of his vacation on the campus. Mr. Handley is in the production rubber compounding department of the Firestone Tire and Rubber Company at Akron, Ohio. MR. WILLIAM J. MICHEL (B.Ch.E., 1929) recently spent a few hours in the chemical engineering department. Mr. Michel is now Sales Engineer with the Duriron Company, Inc., of Dayton, Ohio.

DR. T. M. LOWRY of Cambridge University is on the chemistry staff for the summer quarter. He will make week-end trips to the following cities of the United States: Cleveland, Pittsburgh, Chicago, Rochester, and Schenectady. He will sail from Montreal sometime in September.

DR. PAUL H. MAUTZ (Chem., 1929), of the Bureau of Mines, visited the department on July 17th.

MR. LOWELL H. MILLIGAN (Ch.E., 1916), who is with the Norton Company of Worcester, Massachusetts, spent a portion of his July vacation in Columbus.

The following changes in title were recently authorized by the board of trustees of the university: DR. J. B. BROWN from assistant professor to associate professor of physiological chemistry and DR. HELEN L. WIKOFF from instructor to assistant professor of physiological chemistry.

DR. C. S. SMITH and DR. HELEN L. WIKOFF are the authors of "Practical Materia Medica," published by Lea and Nediger. The book came off the press on July 29th.

The students in metallurgy took their spring inspection trip during the week of June 9th under the direction of PROFESSORS W. J. MCCAUGHEY and W. A. MUELLER. This trip included the metallurgical industries in and about Ontario, Ottawa, and Toronto.

PROFESSOR R. A. MORTON of the University of Liverpool gave a summer quarter course in the department of chemistry.

Rutgers University. DR. WILLIAM THORNTON READ, formerly head of the department of chemistry at Texas Technological College, has been appointed dean of the newly organized School of Chemistry at Rutgers University. In announcing the establishment of the School of Chemistry, DR. JOHN M. THOMAS, president of Rutgers, declared that the advice and active coöperation of representatives of the leading chemical industries in New Jersey had been enlisted in the organization of the school.

"New Jersey ranks among the first of the states in the chemical industry," he said. "There is hardly an important chemical manufacturing corporation in the United States which does not have a plant in New Jersey. It is this great industry we hope to serve in a more effective way by the organization of a School of Chemistry."

Dr. Read was for seven years a member of the faculty of Yale University and went to Texas Technological College as a member of its first faculty in 1925. During his stay at Yale he attracted the attention of the chemical industry by

taking his students several times to New York for the entire week of the National Exposition of Chemical Industries. He was made a member of the advisory board of the exposition and has been since 1923 chairman of the students' course of the exposition.

His work at Rutgers will include not only the training of Rutgers students of chemistry, but also of organizing an extension program of instruction of chemists ranging from the humblest plant man to the highly trained technical graduate.

University of California. We learn from *Science*, via *The Experiment Station Record*, that leave of absence has been granted DR. W. P. KELLEY, professor of agricultural chemistry, to undertake a survey sponsored by the American Society of Agronomy in coöperation with the university as to the present status of nitrogen fertilizer research in the United States and Europe.

University of Colorado. HENRY KARL STAEHLE and JOHN JAMES MCKINLEY have recently been awarded research fellowships in chemistry in the graduate school.

University of Mississippi. A political upheaval in the state of Mississippi recently resulted in the removal or demotion without warning of twenty-four members of the faculty of the University of Mississippi. The only apparent cause for this action was the failure of these men to support zealously the political faction now in power in the state. DR. ALFRED HUME, chancellor of the university, was the first to be dismissed. Six of the ten deans lost their positions as such, four of them being dismissed from the university.

The dismissal of DR. JOHN NESBIT SWAN, whose long and valuable service as head of the department of chemistry of the University of Mississippi was thus abruptly terminated, is a source of particular regret to the readers of the JOURNAL OF CHEMICAL EDUCATION, of which he is a contributing editor, and to the members of the Division of Chemical Education of the A. C. S., of which he is the present chairman. This late and unforeseen action leaves Dr. Swan's services open for the coming scholastic year.

University of Washington. DR. THOMAS G. THOMPSON, the recently appointed director of the university's oceanographic laboratories in the upper Puget Sound, is now in Europe on a traveling fellowship of the Rockefeller Foundation. Dr. Thompson is making a study of the oceanographic methods in use in the Mediterranean, Central Europe, and North Atlantic laboratories. Dr. Thompson is a member of the staff of contributing editors of the JOURNAL OF CHEMICAL EDUCATION.

Upper Iowa University. PROFESSOR L. E. BLACKMAN attended the nine weeks summer session at the University of Wisconsin in continuance of the course leading to the Ph.D. degree in chemistry.

The campaign for a $300,000 endowment, including a new science hall, for Upper Iowa University was successfully brought to a close on June 20th, with a total of $360,000 pledged. It is planned to have the new science hall ready for occupancy by the fall of 1931. The chemistry department will have one floor of the new building.

Washington University. CHARLES A. NAYLOR has resigned his instructorship in order to accept a fellowship in chemistry. L. A. BURROWS and R. W. GILLESPIE, recent graduates of Drury College, Springfield, Missouri, have been appointed assistants in chemistry. K. G. PLEGER, a graduate in chemical engineering of Washington University, has been appointed an assistant. F. J. GAUSMANN, E. O. HAENNI, E. H. BOHLE, F. T.

BARR, and P. W. SCHUTZ have been reappointed assistants in chemistry. C. L. FAUST, a graduate in chemical engineering, has been appointed to an industrial fellowship in the department of chemistry.

A. H. HOMEYER, a graduate in chemical engineering, has been appointed to a research fellowship in the Chemistry Department of Pennsylvania State College, where he will work under PROFESSOR FRANK C. WHITMORE.

R. G. HEMMINGHAUS has accepted a position as chemical engineer with Monsanto Chemical Works.

E. W. MOCKOBEY has been appointed assistant in chemistry at Missouri School of Mines and Metallurgy, Rolla, Missouri.

YUICHI NAKATSUKA, assistant professor of chemistry, Taihoku Imperial University, Formosa, Japan, visited the department on July 2nd.

At the 57th meeting of the American Electrochemical Society held in St. Louis the latter part of May, PROFESSOR L. E. STOUT presented a paper on Electroplating of Copper-Nickel Alloys.

PROFESSOR H. L. WARD attended the recent Symposium on Colloid Chemistry at Cornell University. He is now at Unadilla, New York.

The University recently received $240,000 from the Rockefeller Board for research in pure science. Of this fund several grants have been made to the department of chemistry for research projects for the coming scholastic year.

Western Reserve University. DR. L. CHARLES RAIFORD, professor of organic chemistry, Iowa State University, has been visiting professor for the summer session of Western Reserve University. Professor Raiford has conducted two courses of lectures: one on "Organic Nitrogen Derivatives;" the other on "Type Reactions in Organic Chemistry." On July 10th Dr. Raiford gave a special, illustrated lecture on "Molecular Rearrangements."

Science has announced that DR. EARL W. PHELAN, of Western Reserve, has been appointed professor of chemistry at the Georgia State Women's College, Valdosta, Georgia.

Yale University. We learn from *Science* that DR. LAFAYETTE B. MENDEL, of Yale, was elected to the staff of the Connecticut Agricultural Experiment Station, New Haven, recently, with the title of research associate in biochemistry. Dr. Mendel collaborated for some years with the late DR. THOMAS B. OSBORNE, who was in charge of the experiment station biochemistry department, in studies of nutrition that commanded world-wide recognition. Dr. Mendel is Sterling professor of physiological chemistry at Yale and chairman of the department of physiology and physiological chemistry.

FOREIGN

Cambridge University. *The Chemical Age* announces that PROFESSOR F. W. ASTON, of Cambridge, has received the honorary degree of Doctor of Natural Philosophy from Freiburg University in recognition of his services to physics and chemistry.

Royal Institution of Great Britain, London. We learn from *The Chemical Age* that SIR WILLIAM BRAGG, director of the Royal Institution, has recently been elected a corresponding member of the Vienna Academy of Sciences. He has also been made an honorary member of the New York Mineralogical Club, a distinction hitherto conferred only upon Madame Curie.

University College. We learn from *The Chemical Age* that on June 26th last, Durham University honored DR. FREDERICK GEORGE DONNAN, of University College, London, with the honorary degree of Doctor of Science in recognition of his researches in practically every branch of physical and inorganic chemistry. Dr. Donnan is a member

of the staff of foreign editors of the JOURNAL OF CHEMICAL EDUCATION.

Beilby Memorial Awards. The administrators of the Beilby Memorial fund, consisting of representatives of the Institute of Chemistry, the Society of Chemical Industry, and the Institute of Metals, have announced awards of £250 each to DR. GUY DUNSTAN BENGOUGH of the Chemical Research Laboratory, Teddington, England, and MR. ULICK RICHARDSON EVANS of Cambridge, according to an announcement in *The Chemical News*. The fund was established in 1926 as a memorial to the late SIR GEORGE BEILBY, distinguished chemical engineer, and is to be used for awards to British investigators in science, preference being given to original research in problems of fuel economy, chemical engineering, and metallurgy. Both the recipients of the present award are metallurgists and have accomplished notable work on corrosion problems.

Achema VI Exhibition of Chemical Apparatus. This jubilee exposition was held at Frankfort a/M, from June 10th to 22nd. It is estimated that it was witnessed by about 40,000 persons. The exhibit was international in character, exhibits from many countries having prominent places. Special emphasis was laid on the history of chemistry to show the development of chemical technology that has come about through the cooperation of engineers with classical chemists. Of particular interest in this connection was the model of Liebig's laboratory in Giessen in 1842, with its details of contemporary methods, placed in contrast to a collection of letters, books, and writings embracing chemical research up to the technical literature of the present day. The Verein Deutscher Chemiker and the Verein Deutscher Ingenieure presented a joint exhibit with the Deutsche Gesellschaft fur chemisches Apparatewesen, which organized the Achema VI.

University of Munich. We learn through *Science* that a new zoölogical institute and a combined physical and chemical institute will be erected at the University of Munich through funds given by the Rockefeller Foundation. This arrangement supersedes the previous plan to provide for the two departments of the university by making additions to the Wilhelminum, the Renaissance palace in the Neuhauserstrasse, a plan which is said to have been opposed by Munich artists and friends of art.

Second Scientific Congress, Mexico. We learn from *Science* that the scientific society "Antonio Alzate" has organized a second scientific congress to be held in the city of Mexico from September 9th to 15th. Scientific excursions and visits to museums, libraries, etc., have been arranged. The congress will meet in eight sections, one of these being devoted to physics, chemistry, and physico-chemistry.

New Machine Shapes Liquid Iron in Permanent Mold. No longer must temporary sand forms, which are destroyed as soon as molten metal hardens in them, be made for every object cast.

Small articles of low-melting-point metals have been die cast for years. Now there is in use in Europe a machine which forms articles from cast iron, a high-melting-point metal, continuously in the same mold.

"Machines of this type will undoubtedly be installed in this country in the near future," recently predicted Charles Pack, New York consulting engineer.—*Science Service*

Recent Books

The Construction and Equipment of Chemical Laboratories. A Report of the National Research Council Committee, consisting of L. M. DENNIS, Cornell University; C. R. HOOVER, Wesleyan University; L. W. MATTERN, McKinley High School; J. N. SWAN, University of Mississippi; and G. L. COYLE, S. J., Georgetown University, *Chairman*. First edition. The Chemical Foundation, Inc., New York City, 1930. xiii + 340 pp., including a subject index. A separate index (8 pp.) of dealers in laboratory equipment and apparatus is furnished. 124 figures. 15.5 × 23 cm. $1.00.

The members of the committee discuss: the planning, arrangement, type and location of the building, its ventilation, heating, lighting, and the equipment of all rooms, as well as the materials for building and equipment. Chapters, or parts of chapters were contributed by coöperating authors upon the following laboratories for various special purposes: Gas Analysis, M. L. Nichols; Organic Chemistry, G. N. Woollett; Physical and Electrochemistry, V. A. Coulter; Chemical Microscopy, E. M. Chamot; Chemical Spectroscopy, J. Papish; Industrial Chemistry, Unit Process, F. H. Rhodes; Unit Plant, Allen Rogers; Industrial Chemical Laboratories, A. V. H. Mory; Biochemical Teaching, C. P. Sherwin; Sanitary and Biological Research Laboratories, A. B. Wadsworth.

Inasmuch as this report is a coöperative effort there is some duplication of subject matter, and a number of differences of opinion upon the merits of various types of construction and equipment.

In only one chapter, that by A. V. H. Mory, is there an extensive bibliography regarding the type of laboratory under discussion. In one or two other chapters there are literature references on certain phases of the questions that are discussed. Another defect, in the reviewer's opinion, is that the committee appears to have given very little consideration to the merits of steel for the construction of laboratory table compartments, drawers, etc., and for shelving, desks, and other purposes (see, for example: W. B. Foulk, *Metalcraft*, Feb., Mar., April, 1930).

The report gives detailed suggestions not only regarding high-school, college, and university laboratories, but also considers industrial research buildings. The authors have had recent experience in laboratory planning, and they give valuable ideas regarding almost every conceivable aspect of the planning, location, orientation, and equipment of a chemical laboratory. Many valuable specific suggestions are given regarding lighting, heating, ventilation, and equipment of all of the kinds of rooms which are to be found in a chemical laboratory. The need of coöperation between chemist, architect, engineer, and others is quite correctly emphasized.

On the whole the report contains a wealth of practical suggestions, and every one who has a part in the planning of a new laboratory or the extension of an old one would be well advised to study it carefully.

N. HOWELL FURMAN

PRINCETON UNIVERSITY
PRINCETON, NEW JERSEY

General Chemistry. HARRY N. HOLMES, Professor of Chemistry in Oberlin College. Revised edition. The Macmillan Company, New York City, 1930. x + 654 pp., 167 figures, 14 × 21.5 cm. $3.50.

In this revised edition, Dr. Holmes has arranged the subject matter in forty-eight chapters, followed by an appendix containing a good description of hydrogen-ion concentration in terms of pH values; tables of melting points, gas weights,

solubility products, conversion of weights and measures, and relative costs of some important chemicals. In the index, boldface figures indicate the most important references. The inside cover pages contain tables of solubility, periodic classification, and atomic weights. The printing, quality of paper, and binding is of the usual high Macmillan Company standard, and gives promise of durability.

There has always been a difference of opinion as to how many pages and what subject matter should be included, from the mass of chemical information, in textbooks for college students. Dr. Holmes has selected, much as in his first edition, the high spots according to the standardized historico-systematic method of teaching chemistry, and has included much of the new material. His effort to interest students, by reference to topics with which they have become familiar in their previous daily life, by brief general and specific historical references, and by well-selected illustrations, many of them unique, has apparently been successful.

After the first chapter devoted to Basic Principles, Chapter II has to do with the Atomic Theory, and Chapter III with Symbols, Formulas, and Equations. Some of the fundamentals are very well developed. Fortunately, these chapters are short, comprising in all twenty-four pages. A few exercises are placed in the body of chapters to stimulate thinking, and many exercises and references are to be found at the ends of chapters. Chapter IV, comprising 23 pages, deals with Oxygen and Ozone, Chapter V with Gases, Liquids, and Solids, Chapter VII with Valence, VIII with Water and Hydrogen Peroxide, IX with Carbon and Its Oxides, and X with Molecular and Atomic Weights. Chapters following deal with the topics common to college chemistry texts and also with Solutions; Ionization; Applications of the Ionic Theory; Structure of the Atom and Radioactivity; Equilibrium, Nitrogen Fixation; Alcohols, Acids, Fats, and Soaps; Carbohydrates; Cellulose and Its Esters, Rayon; Food and Nutrition; Photochemistry; Colloid Chemistry; Metals and Alloys; Electrochemistry; Aluminum, Dyes, Cement; and Vanadium, Molybdenum, Tungsten, and Uranium.

There is a little space devoted to the electron theory in the second chapter and again in chapters on valence and the ionic theory. Although a statement is made in the preface that a comparison of "the octet theory and the Bohr theory is offered with the warning that the final theory is still in the making," the reviewer feels that the student should also be informed as to the Schrödinger theory and the conclusions regarding electrons as arrived at in the Electronic Laboratory of the American Telephone and Telegraph Company. One could conclude from the statements throughout this text that electrons are a form of energy. Some of the newer theories are incorporated to too great an extent in chemistry texts, when the evidence on which they are based is very complicated or indirect. The student cannot, really, apply them to advantage and something else, more comprehensible and more valuable is often excluded, or the number of pages is increased greatly. Fortunately, Dr. Holmes has not included much of such theories and he has not endeavored to apply them to the confusion of the student, nor has he left out the fundamentals by which the student's progress can really be measured.

Little differences or inaccuracies of expression occur, such as "cemented roads" on p. 1, and "light also causes wall paper and curtains to fade" on p. 3; also, on p. 18, some teachers would probably express the idea that electrons are associated with all matter instead of "exist in the atoms of all matter"; and on p. 26 some would prefer the term obtaination (although not yet much used) in referring both to how elements are obtained from compounds or separated from mixtures. On p. 58, there is a

slight but obvious misprint in development of Van der Waal's equation. On p. 65, the first two sentences of exercise 7 could better be eliminated. On p. 205, the wording near the end of the first paragraph is not correct, likewise near the top of p. 206. Near the middle of p. 226 there is one of the very few but obvious slip-ups in proof reading. On p. 307, paragraph 1, sentence 2, other wording would perhaps be better. Other possible changes could be made on pages 413, 583, 591, and 603. A statement on p. 4 that "about ten of the elements are gases" might better be "ten of the known elements are gases." On the same page also, the statement, "Rutherford observed a slight but distinct decomposition of nitrogen, aluminum, sodium, phosphorus, boron, and fluorine," would, perhaps, have been better left out, unless the student is informed into what they were decomposed.

Considerable use of graphic formulas is an advantageous feature. The book is up to date, very much so, and includes references to para-hydrogen, "dry ice," vitamins, the work of Bergius, etc. Valence, photosynthesis, foods and nutrition, and colloids are very well treated and some topics are included which are usually found only in physical chemistry texts.

Chemistry teachers will read this book with interest and mental profit. Many will use it in their classes. Industrial chemists and others interested in general chemistry should read it. Finally, and most important, the student of chemistry who studies it, who is interested, who has a little guidance by a conscientious teacher (as most students of chemistry have), and who applies himself; that student will have acquired a great mental asset. The reviewer recommends it to all interested in general chemistry as an exceptionally good text, teachable from an inductive teaching viewpoint, as a second book of chemistry.

C. A. BRAUTLECHT
UNIVERSITY OF MAINE
ORONO, MAINE

A Laboratory Manual of Qualitative Analysis. FREDERICK W. MILLER, JR., Ph.D., Assistant Professor of Chemistry, New York University (University Heights). First edition, The Century Co., New York City, 1930. xiii + 233 pp. 8 figures. 13 × 20 cm. $2.00.

In preparing this laboratory manual to accompany his "Theory of Qualitative Analysis," the author confesses to the influence of the text by A. A. Noyes which he has in the past used in his classes. To any one who is familiar with the excellent manual by Prof. Noyes this influence is noticeable, not only in the chemical procedures but also in the arrangement of the accompanying notes and questions. The author has introduced innovations, however, and made several changes in the procedures, and the general excellence of the manual undoubtedly lies in its conservative treatment.

Following a brief chapter on laboratory technic, the author gives a series of preliminary test-tube experiments for the purpose of showing the characteristic reactions of the cations. This is followed by the systematic procedures. Explanatory notes accompany the procedures and are referred to directly by encircled numbers. Accompanying each group of procedures is a tabular outline of the group and, as a further aid to the student, a chart or "flow sheet" is appended which uses that method of tabulation first described in the literature by Prof. Hodge [J. CHEM. EDUC., **6**, 242 (Feb., 1927)] and also used by W. W. Scott in his "Elements of Qualitative Chemical Analysis."

Important differences in the separations from those used by A. A. Noyes are as follows: 1. Sodium hydroxide is used to separate the copper-tin groups. This brings mercury mostly into the copper group but avoids the large precipitate of sulfur when the tin group solution is acidified. 2. Bismuth, copper, and cadmium are precipitated from lead by excess

sodium hydroxide. 3. The cyanide method is used to separate copper from cadmium. 4. Phosphate is removed by the basic acetate method directly following the analysis of the copper-tin groups. This does not give as satisfactory a test for aluminum or chromium but does not cause possible division of the alkaline earths into two groups. 5. A somewhat different systematic treatment of the chloride group is used.

A few criticisms may be made. In the first place, in view of the fact that the author's accompanying volume contains a discussion of various phases of the ionic theory, it is disappointing to find that in the laboratory manual nearly all equations are written in the molecular form. It seems almost self-evident that ionic reactions are best expressed by ionic equations and it is the reviewer's opinion that such equations not only come nearer to expressing true chemical changes but are easier to write than molecular equations. By using ionic symbols the author would avoid his confessed difficulty (p. 39) of expressing solutes in his tabular diagrams.

It is also unfortunately true that however much a good photograph may appeal to the esthetic sense, it seldom gives as much information as a more prosaic pen-and-ink diagram. With the possible exception of Figures 3 and 7 (and these are marred by poor backgrounds) the photographs in the book fail appreciably to amplify or clarify the text. It seems hardly necessary to include a photograph (Figure 1B) showing how a filter paper is inserted in a funnel, and The Fluoride Test (Figure 6) and The Borate Test (Figure 8) are essentially identical. Neither shows clearly the construction of the tube used for the test.

As a final criticism, the equilibrium $H_2S \rightleftharpoons 2H^+ + S^=$ (p. 55) is decidedly misleading even though accompanied by the statement that the ionization really takes place in two steps.

As a whole, the book is to be highly recommended to the teacher of qualitative analysis who desires a conservative laboratory treatment of the subject, a set of procedures which are thorough and reliable, and accompanying notes which give concise yet clear discussions of all the major chemical changes.

STEPHEN G. SIMPSON
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASSACHUSETTS

Colloids. H. R. KRUYT, University of Utrecht. Translated by H. S. VAN KLOOSTER. Second edition, John Wiley and Sons, Inc., New York City, 1930. xiii + 286 pp. 118 figs. 15 × 23 cm. $3.50.

The general plan and arrangement of subject matter differ but little from the first edition which appeared in 1927. The chapter and topic headings are almost identical with the previous edition, the increase in content amounting to twenty-four pages. The most important changes are the discussions dealing with the electric double layer, peptization, and the kinetics of flocculation.

In both editions the author has chosen "the methods of physical chemistry to outline the path along which the study of colloids should be pursued," so that this text is suitable only for students who have had a course in physical chemistry. Those who have been using the previous edition will welcome this revised and enlarged text.

D. C. LICHTENWALNER
DREXEL INSTITUTE
PHILADELPHIA, PA.

Annual Survey of American Chemistry. Volume IV. July 1, 1928–December 31, 1929. Edited by Clarence J. West under the auspices of the Division of Chemistry and Chemical Technology of the National Research Council. Published for the National Research Council by the Chemical Catalog Co., New York City, 1930. 549 pp. 13 × 21 cm. $4.00.

This volume of the Annual Survey has been extended to cover a period of eighteen

months in order that succeeding volumes may review the progress which has been made during a calendar year. Reviews of 43 fields of chemical investigation and technology are presented.

In accordance with the policy previously adopted, the fields selected for review are not in all cases strictly those reviewed in previous years. "When the work published in a given field does not warrant a review each year, that chapter is omitted and some other field is selected for review."

Thus, the following chapters which appeared in Volume 3 are omitted from Volume 4: Phase Equilibrium Data; Analytical Chemistry of the Common Metals; The Inorganic and Analytical Chemistry of Silver, Gold, and the Platinum Metals; Inorganic and Analytical Chemistry of the Rare Metals; Aluminum; Lead; Magnesium and Beryllium; Zinc; The Rare Earths; Nucleic Acids; Nitrogen Fixation; Structural Cements; Lime and Gypsum; Paint and Varnish.

The chapter on "Physical Chemistry of Electrolytic Solutions" in Volume 3 is replaced by a chapter on "Solutions" in Volume 4. "Thermodynamics of Chemical Reactions" is replaced by "Thermodynamics and Thermochemistry." "Sugar Chemistry" is omitted but there is a chapter on "Carbohydrates." "Water and Sewage" is split into two separate chapters. "Insecticides" has been extended to include fungicides as well.

New chapters are as follows: Gases and Gas Mixtures; Photochemistry; X-Ray Examination of Materials; Electrochemistry; Oxidation - Reduction; Potentials; Nickel; Stereochemistry; The Vitamins; Solvents and Lacquers; Synthetic Resins.

These volumes continue to furnish specialists an excellent means of maintaining an acquaintance with progress in fields other than their own, and for the teacher they constitute an invaluable bird's-eye view of the onward march of American chemistry as a whole.

OTTO REINMUTH

Associate Editor

BULLETINS

Notes on Hydrogen-Ion Measurement. Notebook No. 3, 1930. Leeds & Northrup Co., Philadelphia, Penna. 48 pp. 13.5 × 19.5 cm. Gratis.

"The specific purpose of the Notebook is to furnish information that will be helpful to the large and rapidly increasing number of individuals interested in measuring the acidity and alkalinity of water solutions by electrical methods. The scope of the publication is indicated by the following list of topics discussed: Meaning of Hydrogen-Ion Concentration and pH Value; Electrometric Hydrogen-Ion Measurements; Hydrogen Electrode; Calomel Electrode; Potentiometer Principle; Assembly for Hydrogen-Ion Measurements; Quinhydrone Electrode; Quinhydrone pH Indicator.

"The major portion of the text is devoted to a description of apparatus employed for measuring hydrogen-ion concentration or pH. It tells not only what the apparatus is but how it is used and what its limitations are. This part of the Notebook is equivalent to a manual of operating directions.

"For the benefit of those who want to know why as well as how things are done, fundamental principles are briefly discussed. An attempt is made to present these in a manner and in terms which are comprehensible to one not an expert in such matters."

Handbook of Scientific and Technical Societies and Institutions of the United States and Canada. *Bulletin* of the National Research Council, Washington, D. C., No. 76, May, 1930. Second edition. American section compiled by CLARENCE J. WEST and CALLIE HULL. Canadian section compiled by NATIONAL RESEARCH COUNCIL, CANADA, 352 pp. 17 × 25 cm. $3.00 (paper), $3.50 (cloth). *Bulletin* is well indexed.